

THE FAITHFULL SURVEYOR:

Discovering
Divers errors in *Land-measuring*;

And shewing
How to measure all manner of ground, and to plot it, to fence it,
and to prove the fentring, by the Chain only; as quickly,
exactly, and with less help then with any instrument
whatsoever: as also to take distances of a mile-
space by the Chain without measuring
of them, and the situation of
any building.

Teaching likewise
The making and use of a new and general Instrument, cal-
led *A Pandoros*, which, as exactly and with less
charge, supplies the use of the *Plain-Table*,
Theodolite, *Quadrant*, *Quadrat*, *Cir-*
cumferentor, and any other ob-
serving Instrument.

To this is added
A Discovery of divers secrets touching conveying and cleansing
of water, flowing and dryning of grounds,
quenching houses on fire, &c.

With
An Appendix unfolding errors in board and timber-measure,
with directions for making a *Carpenters-Ruler*.

By **GEORGE AYVELL, alias WELLS**, now
Teacher of the *Mathematick*, in
C A M B R I D G E.

Printed for the Author, at the charge of *Nathaniel Rowles*, Doctor of Physick.
M D C L V I I .

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SIR V. E. YOUNG

Editor

David Brewster's

Life and Letters

of Sir David Brewster

and his Friends

1832-1868

Edited by

John Brewster

and others

London

1870

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and other illustrations

and a portrait

of the Author

and a portrait

of the Editor

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of the Rev. Dr. John Brewster

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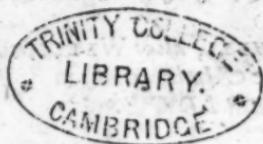
of the Rev. Dr. John Brewster

and a portrait

of the Rev. Dr. John Brewster

and a portrait

of the Rev. Dr. John Brewster



To the Reverend, and his highly
honoured friend,

WILLIAM DILLINGHAM,

Doctor of Divinity, and Master

of Emmanuel Colledge in

CAMBRIDGE.


That speech of him was neither false, nor frivolous, who said, *Librorum fortuna nihil feret à liberorum conditione dissentit: in his edendis insudat corpus; animus in illis astuat.* And, as there is need of a *mid-wife*, to help bring them forth: so is there also need of a *nurse*, to help attend and defend them. Sir, you have been the *mid-wife* (I must needs confess) already, without whose help (I dare boldly say) this piece had never seen the light of the Sun. I see a company of sorry *Pamphlets* daily come forth with easie passage; that neither benefit *Church*, nor *Common-wealth*, and are good for nothing but to corrupt the minds of youth: *Eunuchi gignunt, steriles pariunt: plures hac atas moratur, quibus nulli tales in uno anno extrusit, quam quibus ipsa Arithmetica sufficiat enumerandis;* So that we may well take up the complaint of *Famianus Strada, Obruiuntur libris, oculi legendo, manus voluntando dolent.* But as for this work, notwithstanding that not I my self alone, but also all that have seen it, do Judge it to be both as necessary and beneficial to a *Common-wealth*, as any at this day extant; and the matter whereof it treats (for the most part)

The Epistle Dedicatory.

such as was never yet handled by any; (as measuring of all kinde of ground by the Chain onely, as quickly, and exactly, as by any *Geodetical Instrument* whatsoever, And what can be more beneficial then quenching an house on fire? with divers other such Problems.) Yet, not onely this, but several other pieces, as commodious and beneficial to a Commonwealth as this is; as, *My direction and method of teaching school*: (which your self, Sir, have both read and examined; together with another piece of *Common Arithmetick*, and *The Doctrine of Triangles*, and a fourth piece of *Dialling*.) whereof both the Reverend Vice-chancellor, and others the Heads of the Universitie, have so willingly and freely long since granted me their hands for licence of impression; hitherto have wanted the good hap of being able so much as to crack the shell, till now that this is got forth and flown abroad; but at Doctor Rowls his cost: for amongst all our Book-sellers none would ever bid me a penny for my copy; so that I have lost all mine own labour, and a great deal of charge in transcribing; so that had not Doctor Rowls beg'd a pardon for it, it had gone to the pot. When the other will be printed, God knows, they are ready: *the children are brought to the birth, but there is no power to bring forth.* I fear I shall not speed so well, as the report goeth of a *Kentish Carpenter*, who going from home on Mondays, and coming home on Saturdays; for a moneth together, each severall Saturday his wife welcomed him home with a new babe. If I could have but one of these in a moneth, I should think it well. And since this is born, it must be kept: therefore my humble request to you is, That you would be pleased

The Epistle Dedicatory.

pleased to take it into your protection; though I am not able to put it in so fine a dress as others can, yet remember (I beseech you) *Sub fardida veste sapientia scientia*. You are the best able to protect it, of any I know, in regard of your excellent knowledge in all kinde of good learning; and more particularly (which is the main reason of my taking Sanctuary at your Castle,) in *Geodesie*, the subject matter of this Discourse, which I know, your love is such to the furtherance of all good Arts, that you will not refuse to harbour and shelter. Which so accepting, you shall for ever oblige,

Your most subject

servant.

GEOV. ATWELL.

The Author to the Reader.

Courteous Reader,

 Ad 1 fancied the giddy humour of obscure wits, who deliver their dry notions as dubiously, as the deceitfull Oracles did their responses of old; lest by speaking too plain their shallowness be made manifest to all men: I might have spoke as little sense in as few words to as little purpose. But (leaving these to their folly) I never accounted their design either prudent, or politick, who, having enlarged their stock of knowledg by the good improvement of their opportunities, deliver themselves so darkly to the world, as if they had a mind onely to satisfie it what they could do, and not what they shou'd. I like Pythagoras his counsell, *χρηστὸν ἀποκαλεῖν οὐδὲ λέγειν*. Either speak to purpose, or hold your tongues: and, methinks, his counsel pleases me the better, when I remember the curious Naturalist's observation, That men have a double fence to keep in this slippery member; which insinuates thus much to us, That one had need be wary,

Πλούτιον εἰς τὸ φύγαν ἐργάζεσθαι τοῦτον. What and How he
speaks. Now, to walk secure from the default of each of these
by-ways is the drift of my present writing: which, had not
the profit of others more stirr'd me up to; then the profit,
pleasure, or honour I could have proposed to my self in such
an enterprise, it might have lain buried in oblivion: but I
remembred that saying of Tully; *Non nobis, sed patriæ*
nati sumus. The Law of humanity enjoyns us all with one
shoulder to help forward any usefull or profitable design, and
to treasure up our notions and observations for the good
of others. Condo,

Hom. O-
dys. Y'.
v. 230.

To the Reader.

Condo, & compono, quæ mox de promere possum. *Hinc.*

I lay up, that I may lay out: and we never so well dis- ^{EP. I.}
charge our selves of our talents, as when we most largely dis- ^{lib. 1.}
fuse them to the improvement of humane society. Seeing
then my lot is fallen among the scribblers of this present age,
I make a double request to two sorts of Readers. First, To
the ingenious Scholar, who may, perhaps, nauseate this
homely fare & domestick language, and may, "tis not un-
like, finde flaws in the unwary connexion of the sense, or
unpolished contents: my Apologie is only this, that I write
to be understood of all, and so bent my country-stile to the
capacities of those I supposed would chiefly put the contents of
it in practise. My Second request is to the honest country-
farmer, or whosoever he be who intends to mine his ground
by my chain; that he would go through with it, and make it
his own as he goes: for by so doing he may finde benefit affi-
redly. My last request is to both joynly; Not so reject the
grounds of it without good reason, nor without a pair of spec-
tacles to convince experience, *untria illa textrar*, the mo-
ther of Arts, as the Philosopher calls her. I might put
this into the ballance to weigh down the censure of both,

— upon the yearique èor èquio.

but I forbear, lest I should tire the Reader's patience with too
tedious a Prologue, letting truth stand on its own bottom:
and commend it in general to the well-improvers of it, and
rest thy friend to serve thee,

G E O R G E A T W E L L.

The

The Author to his Book.

Go, little book, and travel through the land;
None will refuse to take thee in their hand.
Fear neither Momus mouth, nor Zoius quill:
Assuredly, there's none, can do thee ill.
Both simple, gentle, Barons, Lords, and Knights,
Will take thee for the chiefeft of delights.
Thou teachest them to measure all their ground;
Which, certainly, will save them many a pound.
Plain-Table, and Pandoron with its light,
Circumferentor, and Theodelite,
Quadrat, Quadrant, and Chain alone; with these
Thou'lt teach them how to meassur with great eas.
Some give a penny to a fire that's past:
But thou giv'st pounds, for to prevent the waſt.
Thou cleanseſt waſer, flowſt and drainſt their grounds;
And bringest waſter plenty to their Towns;
Thou teachest alſo to enrich their mold:
And iſh mean while to fill their cheſts with gold.
Thus doing, thou ſhalt never be forgotten;
But thou ſhalt live, when I am dead, and rotten.

G. A.

Upon his worthy Friend, Mr. George Aswell,
and this his exact Method of
Surveying.

So, now the Pres^t ha's a new labour past,
Which shew'd her best acknowledge, if not last.
Ne're did her letters such a posture show,
So advantageous, since they first did know,
T' instruct she wld how they their Acres should
Cast-up and measure by the perch or rood.
T'was but of late, since which applause we view'd
Some labours in this kind, and thought them good:
But they themselves will now no more aspire
To further praise; but all consent t' admire
Content, since thou art come. So when we spie
A curious piece, that entertains our eye
With livelyness, w' approve't; yet, when we pass,
Forget it in a livelier pieces art.

Me thinks, I see how with a glance meu lay
Others aside, and by their longer stay
Speak their contentment of thy book, and stand
Surveying that as thou of late their land,
With such exactness. -- Here thine art is by thee
So rais'd, that truth meets with facility.
Before we did by Sines and Tangents go,
Theodelete, Circumferentor too;
Wayes^s that I sigh to think of: which at th' sight
Of th' marshall'd figures able were t' affright
An unassured eye: who without fear
Gainst such a rallied number dar'd appear?
Atmies of figures in the field then stood,
Fore-sight it was (though without fear of bloud).
To reach an * herb; a sign we could not know
T' o'recome that bed, where lately it did grow.

* Her-
bam por-
rigere.
Prov.

This

*This by thy chain alone thou do'st; and we
Admire thine art, admire thy brevity.*

*Men of thy temper, and that owns a mind
As thine, so searching, we may seek, not find:
At thoughts of it we can scarcely cry,
Th' auctorit mind still ha's the piercing'st eye.*

John Hutchinson, *Trin. Coll.*

To his honoured friend, M^r. George Atwell,
on his *Faithfull Surveyour.*

See the stile alters; Poets did but feign:
Counter-Pandora with her box again.
Salsbury-stones, that pos'd the baker's loaves,
Might here have set themselves in these thy groves.
Thy hand hath meted, and be sure to try
There's no thing isn't but squar'd by Geometry.
But sound thy Art, and teach us how to get
Some lands, as thou hast taught to measure it:
For, while we other's mete, our spirits rise,
And in their acres we but Tantalize.
Yet, 'tis too true, estates take no degree
Ith Confines of our University.
He, who was ask'd, Where our possessions lay,
Might well have thus resolv'd, In Terr' Incognita,
Or, in the Isles, that well may bear the date,
From their unlucky seat, Infortunate.
Help out, invention; and affst, ye bands:
'Tis Scholars fate, you see, to have no lands.
If any they appropriate will have,
They must, Ben-Syra-like, mete out their grave:

Or

Or else, if all plots fail, may try their skill
To take the angles of Parnassus hill:
But wee'le suspend our judgment, and not dare
To question, till we see thy Finis there.
The Welsh-mans sentence was content to stay
The Apostles leave till the Judgement-day;
And, shall not we with patience wait to see
The true Effigies of thy Art and thee.
Till then wee'le try our skill, no spirit raise,
Without a Charm, t'encircle thee with bays.

I. Charles, T. C. Philomath.

To the praise of the Ingenuous Book of his
honoured friend, Mr. George Atwell, call'd
his *Faithfull Surveyour*.

On the Authors name,

GEORGIVS ATWELL.

Anagram.

AGROS E VULTU LEGI.

His book's thine own, none need to fear,
Each leaf thy picture isn't doth bear.
It's the Idea of thy mind,
And face to both are here conjoyn'd.

On his Book.

I Do not wonder that Medusa's head
At sight could render living mortals dead ;
Since the perusal of this book (whose vein
The richest gems of wisedome doth contain)
I seeing wondred, wondring dead I fell,
To view so much lockt in so small a shell.

On the Author.

WHat splendour can, or Jove, or Saturn add
(who borrow all) to Sol most richly clad
In golden vestments? to Sol, whose rays
Each morn foretells to all their Halyon days?

Muse. T'averre he wants no praise.

WHat glory then (dear Muse, I priche, tell)
To him (whose name subscrib'd shows all's done well)
Ought we to give? to him, whose programs wit
Shall live, while others may in silence sit.

Muse. On earth there's none, that's fit.

On earth there's none, that's fit? then soar the skies,
Brave George! whose fame beyond the clouds dath rise
In spight of envies Clog, and does aspire
Heavens Canopie beset around with fire.
Thither thy self retire.

D. Jenner, A. B. Trin. Coll.

To his much respected Friend, M^r George Atwell,
upon his Book Of Surveying, &c.

To dress my lines in praise of Thee, my quill
I de wish to dip, where Poets once did fill
Their versing pens; whose thoughts when they d'rehearse,
Like metall in a mould would run to verse:
I de shew my self then graterfull to Thee,
Then these detracting times could spitefull bee.
Here you the Curtian draw, and let us see
The now-known worth of conceal'd mysterie.
'Twas Nature form'd the Earth, gave treasure:
But how to give the price, and measure

With

wish lines unparallel'd th' embroidered ground;
 To G E O R G E alone his praise it must redound:
 'Tis A T W E L L gets the start of Fancies yis'd;
 They at HIS publisch work may stand amaz'd.
 Let all the B O O K now view; give her the praise,
 That made the tools: but reach to him the bays,
 That is the Artist, and who undertook
 To make himself the Author of this Book,
 To dissolve Riddles, make Enigmas plain,
 Which have requir'd an OEdipus his brain.
 Envy, be gone, Apollo; be their guide:
 To see what Gordian knots are here untye'd;
 And conched handsomely what might in short
 Please both the Learned and the Vulgar sort.

H. Rich, A. B. Coll. Gen. & Cais.

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Addenda & Emendanda.

Gentle Reader,

I desire thee to take notice of these my *Additions*,
and *Emendations*, before thou readest my
Book.

G. A.

Page 9, l. 8, for first, read where. page 14, line 18, p. 130 note, page 31, for sub-tendents C X 674, and 756, which are at the top of the third column, set them at the bottom of the first and second columns. 9, 27, against line 31, dec. fit in the margin, To bring links into acres and poles. p. 28, l. 3, for 7, read 77, p. 36, l. 23, after quadrant, read book or pastboard, p. 37, l. 2, read, tran vit, from the line drawn, p. 42, l. 10, for 19, r. in. and line 15, likewise you may, and l. 33, r. to the line, p. 43, l. 11, r. a spinny of wood, p. 45, l. 11, r. save only if in measuring you have any sorry bound book or pall-beard; and against line 23, write, How to set out a perpendicular into an angle with the chain only, p. 57, l. 18, for mark n. work, p. 63, l. 19, r. the whole angle B, p. 64, l. 10, r. A, I finde, and l. 13, at D, I finde, p. 65, l. 7, for 10, r. 16, and l. 11, & l. 13, for L, r. lin. p. 69, l. 12, for edge, r. eye, and l. 39, r. 100 of the Quadrant, p. 70, l. 34, for you, r. I., p. 72, l. 9, for declination, r. the angle of the wall and Sun, p. 73, l. 10, ponus; As the Radius to the sine of the Suns greatest declination 23, 31, and write it ibm;

As Radius.

To sine of the Suns greatest declination 23 31.

So is the sine of the Suns distance from the nearest Equator.

To the sine of the declination desired

16 960080

96484

93454

p. 74, there is a better figure in pag. 51, p. 78, the commas should be left out, and l. 10, for lines, r. times. p. 85, l. 33, r. a foot and an half long, and l. 36, r. steriles. p. 96, l. 29, for tre-sole, r. trefoot. p. 112, l. 20, for 32 82, r. 23 82,

In the Appendix.

Page 130, line 12, for square, read stroke. l. 15, distinguish at thirds at l. 16, as that, l. 25, for fives, r. fives. l. 30, r. 5, 10, 15, l. 33, for 38 r. 30, p. 135, l. 31, for 2, r. 12, p. 141, l. 20, distinguish at 8, p. 143, l. 9, for set, r. get.

The Faithfull Surveyour.

C H A P. I.

Of errors in Land-measure.



Iverys are of that opinion, That if two pieces of land are of equal peripherie, that those two pieces are both of one and the same content. But that is easily discovered false; for let one piece of land lie in a true square; being a quarter of a mile square, or 80. poles square, *viz.* a mile in all; the content is just 40.acres. For every one knowes, that 40. pole long, and 4. pole broad; or 80. pole long and 2. pole broad, make an acre. Therefore 80. pole long, and 80. pole broad, must needs make 40. acres, and that 80. times 80. is 6400. pole, which divided by 160. (the poles in an acre) is just 40. acres. But in a Circle of a mile about, *viz.* 320. pole, if (according to Archimedes) we multiply the Circumference by 7. which is 2240. and divide it by 22. it gives $101\frac{1}{2}$ the diameter: now then, if we multiply half the diameter 50 and $\frac{1}{2}$, or 50 and $\frac{1}{2}$ by half 320. the Circumference, *viz.* 160. (which are also the poles in an acre) first 160. by 50. is 50. acres: then multiply 160. by 10. *fascis* 1600. which divide by 11. it gives 145. pole and $\frac{1}{11}$. so that the Circle contains more then the square by more then a fifth part. And as in land, so in timber; and therefore that must needs be a false way of measuring round timber, to gird it about, and to take the fourth part thereof for the square, as plainly appears in this; that, when they have hewed it, they make more of it then they made before. Also a square is more capacious then an oblong; for every Shepherds boy can tell,

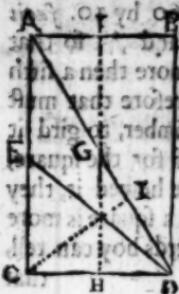
A

that

that if he hath but 24. hurdles in his fold, and that it goes upon a rood, where he hath but one at each end, and 11 on each side; his sheep will lie thicker a great deal, then if his fold goes six on each side, and end: though he knowes not the proportion, yet he perceives a sensible difference, and so well he may, as being more then three to one odds. For it is as 11 to 36. for once 11. is but 11, and six times six is 36. And for want of this knowledge many suffer their sheep in summer, by lying too hot. If I may advise, they shall never lay sheep thicker, then to allow 20. foot of ground to each sheep, so that if you have rod hurdles of 8. foot a piece, viz. 64. foot; in one hurdle square I would not put above 3 sheep and $\frac{1}{2}$; nor in flat hurdles of nine foot long, above four sheep, and so doing, if your 24. nine foot hurdles go square, it may hold 96. sheep, and your 24. eight foot hurdles 84. sheep.

Another great error I have known maintained by a great *Rabbi Surveyour*; that in measuring a triangle, it holds good to take the half of any side for the base, and the whole perpendicular from the angle opposite to that base, to the middle of that base, *et vice versa*, and their product to give the content. But this is demonstrated to be false thus: In this oblong figure A B C D, let the two sides A B, and G D be 30. a piece, and the two sides A C, and B D 40. a piece, so 30. multiplied by 40. gives 1200. the content of this oblong, which is divided into two rectangle triangles, by the Hypotenuse A D, which two triangles A B D, and A C D are both equal; for that the sides A B, and C D are equally by construction, also the sides A C and B D are equal by construction, and

A D is common to both; therefore the two right angled triangles B and C are equal; likewise the two right angled triangles A B D, and A C D are equal; per
2. prop. 4. *Elementa* the 1. *Axiom*. the 7. *Qua
drupla pars ejusdem sunt dimidia, inter se sunt aequalia:
vnde* therefore either triangle must contain 600. Now in the triangle A C D, to discover the falsehood, we must first finde the length of the line



line ED thus. First, square the line CD, 30, *faciſt* 900; also square CE, 20, *faciſt* 400; then C being a right angle, and we seek ED, the Hypotenuse, we must adde 400, and 900, *faciſt* 1300, whose square root is ED 36 $\frac{2}{3}$, multiply this by 20, the half of AC, *faciſt* 721, $\frac{1}{4}$, the content, too much almost by a sixth part, being it should be but 600. and so you shall finde it, if you multiply AC, 40 by half CD, 15, for the oblong AFHC, is equal to the oblong FBDH, therefore it is the half of ABCD. Also the triangle DGH, which is taken out of the triangle DCA, is equal to the triangle AFG, adied to it.

Or if you will make AD the base, upon which you may let fall a perpendicular from the angle C; but then it must not fall on the middle of the line, except it be the base of an Isosceles triangle, but if you will needs finde the true place of the field where the perpendicular must fall, I know no instrument you can work by, be it plain Table, Theodelite, Quadrant, Circumferentor, no not so simple as the chain alone, but you may set out a square by it; therefore set up your instrument in the station-line, going forward straight in it, till you ghuess that a fine out of the angle will cut your station-line square-wise, which if you think you are far enough, set up your instrument there and first let it behold the mark you came from; if it doth not then behold also the mark you go to, you are out of your fine, and must remove it fide-wayes which having rectified it that way, then see if it look right into the corner: which if it do, it gives you the place in the station-line desired, which is 32 from A, and but 18 from D, *viz.* at I, which is thus made good. As the base 50. is to 70. the summe of 30. and 40. the two other sides AC, and CD; so is the difference of the same two sides 10. to 14. which 14 being taken out of 50. the whole base, the perpendicular shall fall on the middle of the remain 36. the half whereof is 18, to which add 14, it makes 32 from A to I, as afore; and that taken out of 50 leaves ID, 18, as afore. Now to finde the length of the perpendicular CI, if you measure it in the field you will finde it 24 pole, which is thus proved. Take the square of the side AI, 32, which is

1024. out of the square of A C, 40, viz. 1600, rests 576, whose square root is 24, the perpendicular desired. Now if you multiply 50 the whole base by 12. the half perpendicular : or 25. the half of 50. by 24, you have 600, as afore. Thus you see it double proved, that this way of taking the middle of the base for the fall of the perpendicular, is for the most part an extream false way: and the sixth part of the ground and more may be easily got and lost hereby: insomuch that I have known by this very error above twenty pounds got and lost in one day between the buyer and seller, severall times, and by severall men. But whether *Balls* of *London* used this way, or worse, I know not, who was sent down by the Lady *Morrison*, to survey a Farm at *Hardwick* near *Shefford* in *Bedfordshire*, whereof she had let a new lease for 21 years to one *Childe* at five shillings the acre. *Balls* makes of it 400 acres just; *Childe* thinks himself wronged, sends for me, desiring me to measure it, not saying a word to me upon what terms, or that it had been measured before. I set to work, and having done, I give in mine account for 322 acres. He asked me if I would justifie it. I told him, I accounted him as my friend, I would stay for satisfaction a twelve-moneth, let him keep my plats, if in that time I were disproved two acres, I would have nothing for doing it. Whereupon he works to the Lady to send another to measure it; but durst not let her know he had measured it; but that his reapers, and mowers, nor his seed never gave it for so much. He prevails with her, she sends another; he measures it, knowing as little of any mans measuring, as I did of *Balls*. Upon his account we two differed but one rood in the whole thing, which he had made it lesse then I did, by reason I measured half *Shefford*-brook more then he did. So I sav'd him 19 pounds ten shillings *per annum*; which if it had been yearly payment, at ten in the hundred, as money was then, compound interest came to above 1200. pounds, but being half yearly payments, nine pounds 15 shillings, half yearly, 42 payments at five in the 100, which was the common reckoning both then and now still for half a year, comes

to

to above 1300 pounds, a good Farmers estate. Therefore it behoves every man that hath, or may for himself or friend have occasion to let or hite, buy or sell land or timber, not to go oh other mens legs, nor to see with another mans eyes, that have such easie means to attain the skill of it themselves. I make no doubt but that there are many Gentlemen, who have spent much time in the Universitie in Musick, yea, and other studies too, do wish at this day, (and more would wish, if they could see it) they had at least spent some of that time in the Mathematicks, whereby they might have benefited both themselves and their Countrey: which in commendations of it, *Pisicus* in his Preface to his book *Geodeticorum* saith, *Socrates hunc principalem Geometria finit esse statuerat, ut agrum planum metiri, dividereque posset.* I have seen some spend eight years in learning Musick; if they would bestow but two years in the Mathematicks, it would have done them more good, and they might have done the Common-wealth good. Of all the seven liberal Sciences that may best be spared, as least beneficial to a Common-wealth; and for my part, I had rather (if you will believe me) that my feet could pace 1000 acres of land of mine own, then my fingers to play 1000 lessons on the best Lute in the town, though I might have it for my labour; and he that is not of my minde, it's pitie, if ever he have 1000 acres, but he should change them for a fiddle. Recreation, I confesse, is good; but I would not have it made an occupation. They will account it small recreation hereafter to be able to say, *Post habui tamen illorum mea seria ludo.*

Divers such falsities I have seen; but I am loth to digresse too much. Divers other false ways there are; but I had rather I were come to lay down true ways, then to discover errors. Therefore that we take not a false way to our purposed end, we will ride streight on to the next town; *viz.* the uncertain ways: where we must stay a little, and give our pen drink too, that so we may the easier finde the true way in such uncertain ways.

First, it is no certain way to lay a great deal of land upon a

little paper, as to work by the scale of 32. as many do, whereby upon each inch of paper they lay six acres, one rood, 24 pole; and it is an easie matter for a good Artist with good instruments to fall an acre in an hundred, much more with so small a scale, and blunt compasses: neither is there any that ever I knew use so small a scale, that can or dare say, that he is able to distinguish a quarter of a pole, whereby oft-times there is six in the hundred got and lost, not in a year, but in a day.

Secondly, To trust onely to the needle in any graduated instrument, as Circumferentor, Theodelete: and partly for fear of a loadstone near, and also it is a hard matter by an ordinary needle, though of four or five inches long, to distinguish a degree, much leſſe five or six minutes.

Thirdly, For over-curious ways, such as if I shall spend so much more time then ordinary, that the gain or losſe will not countervail the time bestowed on it: therefore as upon buying and selling there is some land of 20 or 40 pound the acre: ſome I have measured where every man in the town hath hired the tythe, *communibus annis*, for two ſhillings per acre; others have undertook plowing for 2 ſhillings six pence, others have let for five ſhillings, as the Lady *Morrison* aforesaid. Now I will not stand ſo curiouſly upon that of five ſhillings per acre, nor work by ſo large a ſcale, as for that of 30 or 40 pounds the acre. This comes to five ſhillings the pole, the other very little above half a farthing a pole. Two pole got or lost in the firſt is the Surveyour's ordinary dayes wages, whereas five acres of the other will but do it. Again, as there may be curioſity in measuring, ſo there may be in casting: but let the ſame rule be the guide in both: and although *Pitiscus* hath done exceeding learnedly through all his book, as like a Mathematick Profefſour, and well ſkilled in the doctrine of triangles; yet he that shall ſeek out his ſides, bases, and perpendiculares by Sines, Tangents, or Logarithmes; or cast them up by Logarithmes, as ſome others haue taught of late: yet neither *Pitiscus* nor his followers haue shewn themſelves practitioners; neither of them ever measured, plotted, and cast 900 acres in

three

three days, whereof for a mile together the side was as staight as Hockley-brook, as the Proverb is: (for it was Hockley-brook it self,) yet platted and cast every crook; and so did I Shefford brook also: and Mr. Wingate hath measured 1000 on a day near Biggleswade in Bedfordshire. I denie not but these men may and have good skill in the Theorie, but as little in the Practick as the Londoner, that asked the countrey-Master if malt did not grow uppon trees. Such a London Mathematician (perhaps) was Ball, aforesaid, a perfect Surveyour, but never saw acre of land measured, so that he misled but 78 acres in 322.

CHAP. II.

Of making and keeping the field-book, and measuring pasture by the plain-Table.

S. 1. If you intend to practise Surveying, make you a book of a quire of good strong paper, so folded, that the breadth of the leaves may be in octavo, and the length thereof may be the length of two quarters, well bound with vellum, that you may lay it on your left arm to write: and if it be your first book that you have filled, write on the cover a great (A). If the second (B). On the third (C), &c. Then page your first part of your book (A), all but some 12 leaves at the latter end, on each severall page whereof you shall write a severall letter of the Crois-row in Alphabetical order, and so your book is ready to go to work.

*How to choose their first standing in Pasture-ground
for the plain-Table.*

S. 2. As soon as you come into the field make a mark, as some hole with a paddle-staff, or stick up some paper, or both, at the first corner you come at; which if it be adjoyning in that place to another pasture, then choose your station or hole (if be possible) that it may be right against some gap, gate, or

stile

stile (which commonly in all pastures there are near the corners , or else you will be forced to cut an hole through the hedg with a bill , that so from that station you may see to the further side of that ground , or so far as you can , to strike a line . But let that hole or mark be set four or five foot from any hedg or ditch , so that you may set up your instrument , and have firm standing to see in a streight line to the further side of the ground you are in , both on your left hand , and on your right : so that you touch not upon the hedges , nor incumber your self with wood , bushes , houses , nor waters , though you are driven to go nine or ten poles off at one end , and but nine or ten links at the other . Whatsoever others bid you always go parallel to the hedge , regard it not ; for if you do so , you shall have work enough till Wednesday . What will these men do when they come at *Hockley-brook* ? It will hold them a week to measure a furlong streight , and they have no way left , but onely to equal one place with another by ghuels ; neither , alas poor men ! do they know which way to go about to plot it ; whereby though they do hit the true quantitie by chance , as the blinde man may shott and hit a crow , is that a true plat of the form ? and who knows not but brooks , rivers , & the very seas themselves alter in time , witnesse *Hercules-pillers* ? and how can they go parallel by this whim-wham ? Besides , that by the plain-Table they do plot all as they go , so that they had need have a great deal of fair weather , no dewie mornings : and because they know neither how to measure nor plot such a piece , we have not had one that hath wrote of Surveying these thirty years , but have been all as mute as fishes in it .



CHAP. III.

How to set down your notes in your Field-book, and to draw your station-lines by the plain-Table.

Having made choise of your first station, before you begin to measure, take your field-book, & on the top of the first page write the name of the Parish first the ground lies in. Secondly, the year and day. Thirdly, the name of the close. Fourthly, measured by me, and for *I. R. contra W. R.* or if you are indifferently hired on both sides, write *inter I. D. & D. I.* Fifthly, your directour. Sixthly, your helper. And Seventhly, which way you went forward, whether *cum Sole*, or *contra Solem*: *Cum Sole* in a pasture is, when the hedge is on your left hand; *contra Solem*, when on the right.

Then in your field-book about two inches from the left side of the leaf, draw a line with your pen streight down to the bottom of the leaf, and on the left side about an inch from the line write A, signifying the first station, or the mark you stand on, and close to it on the same side, write O, signifying the beginning of the line; then if you intend to go *contra Solem*, measure how many links are to the hedge or ditch on your right hand, and set them down right against A on the right side of the line; so all your lengths, as you go in the station-line, must be set down on the left side of that down-right line, and all the breadths on the right side. Yet before you go forward, you must know these leveral things.

Prolegomena. First, That always a ditch must be measured with that ground on which the hedge standeth.

Secondly, That you never need set up your Table at A, unlesse there be another close adjoyning, which you are also to measure; nor yet at the last angle: so that if the ground have four angles, you need set up your instrument but at the second and third; neither is there necessitie of setting it up at the third, if you be sure you have measured all the station-lines right, calling your Angles B C D E in order, &c. by reason you may set out the two last station-lines of any ground whatsoever by the scale and compasses, by tranning the first of

them, and pricking the last, as shall be shown more at large, when we come to speak of measuring by the chain onely.

Thirdly, If one of your sides be bushy, woody, watery, &c. that you cannot come at the hedge for such things, leave that for the last, so that it be a streight side; for your plot will give you that side: so that, if you have done all right thitherto, you cannot fail in that, neither need you measure it, save for triall sake.

Fourthly, You must know, that wherefoever you have two closes to be measured joyning together, the station-line in one close serves also for the other, and the additions in one close are the subtractions from the other.

Fifthly, If a fair plot in colours be required, you must still, as you go in your station-lines, take notice and set down in your field-book all Churches, houses, rivers, ponds, gates, ways, paths, stiles, arbors, wind-mills, great singe trees, woods, &c. which fall within compasse of your plot or square, and set them down in your distance from the station-lines. If they be not on the same side of the station-line that the hedge is on, mark them with a crosse, and draw them all in your fair plot in prospective in their proper colours, with their manner of situation, East or West, North or South, and your needle in any of your instruments will help you always, making the North-side of your plot the over end, as you may see in plots of countreys; and at the bottom setting a scale of poles beautified with compartments, and a pair of compasses: but your scale for this plot may (if the ground be very large) be smaller than that you measure by.

Sixthly, Before you begin you must make choise of your scale, wherein you are to consider the bignesse of the ground, the bignesse of your paper, and the price or value of the ground, and whether on purchase, or hirинг, and that for a longer or shorter time; yet howsoever it is good, though it be upon letting, not to be too carelesse in it: for I have been imployed upon letting between Sir John Crofts and Sir William Bryars, yet before they concluded, they agreed on a purchase

by

by the acre upon the same measure ; therefore I seldom measure upon purchase with a scale more then 8, never above 10 in the inch ; nor upon hiring seldom above 10, never above 12.

Seventhly, Before you begin, you must consider whereabouts of your ground you begin, that so turning the length of the Table to the longest way of the ground, and beginning at the like place of the paper as you do on the ground, you may (not taking too small a scale) lay all that ground upon that sheet of paper, or (at least) all that you can measure that day; for it is somewhat troublesome to shift your paper in the field, or to fall beside it for a piece of a close; for which, if you do, we will give you these five remedies.

1. If it be but a small matter, and presently comes on again, you may lift up the rulers, and that paper which they hold down cut it so, that so much as you need may lie upon the rulers.

2. If that will not be enough, you may make your station-line that you came, or else do come on, shorter then indeed it should be by 10 or 20 pole, taking the next angle upon the same line as if it were the end of it; and then making a new plot at home, your own reason will direct you better then I can shew it : for it is easier perceived upon triall in the field, then expressed by word or scheme ; but then you must lay down none but station-lines and angles.

3. The most common help that Surveyours use is to remove the paper nearer one end of the Table, and then with a piece of mouth-glue, which they usually carry with them, they glue on what paper they think they shall need, and then fasten it down with the rulers again.

4. If your plain-Table be also a Pandoron, or have a semi-circle, or a Quadrant, you may at any time, either in this case or case of moist weather, take off your paper, and help your self thereby, as shall be shown hereafter.

5. By the chain onely and your field-book ; whereof also hereafter in its place.

Eightly, Before you begin you must know, that both at the

beginning and ending of every station-line, and every crook of the hedge, both inward and outward, you must measure the nearest distance between the station-line and the hedge (for all breadths must cut the station-line squire-wise) and so make two right angles at the station-line, and that is the best way: and so doing, all the pieces on the out-side of the station-line will be either rectangle triangles, or else compounded of an oblong and a rectangle triangle: the area of both which is found by adding the breadth at both ends together, and take $\frac{1}{2}$ of it for the common breadth, which multiply by the whole length, and you have the content. And sometime your best way to finde the shortest distance into an angle, is to set up the Table right in the station-line: if standing at the fore-mark you see by the edge of the Table the hacker mark, and then standing at the backer end you see the fore-mark, then are you right in the line. If now withall one or both of your other sides look right into the angle, then are you right. And all these lines must be entred into your field-book, which fall perpendicular upon the station-line, every one in their order on the right side of the line, and on the left side right against each of them their correspondent lengths, how far each of them is off from the last station. Or else you may strike a station-line into the angle, and so make scalenumtriangles, but that is not so certain, and asks more labour.

Ninthly, Before you go forward you must propound to your self a mark to go upon on the farther side the ground, or if it be quite beyond the ground, though it be a mile, it matters not: so that standing at A you may see it clear from the hedge, yet as near to the hedge as you can; whether it be parallel or no, care not. If you can see no such mark neither near the further side, nor beyond, then either you must send one before to stick up a stick with a cloth or paper on it; or to stand there till you come, with some white before his breast. And moreover see, if you can see some other mark between him and you right in the same line, be it either flower, weed, grasse, dung, &c to be a guide for the fore-man, to keep him right in the line, that carrieth the fore-end of the chain. Tenthly,

Tenthly, Whereas you must have ten sticks about a foot long apiece, whittled and sharped at the great end, let two take the chain, one at one end, the other at the other: let the former take the sticks, and let him be sure to lead streight in the line, which for his guide therein he hath these helps. First, he must always be right in the line with his two marks *How to* before him, till he comes at the first. Secondly, after he is come at the first, let him every time he sticks down a stick, *set them-selves* *right in a* *line.* look backward to set himself right in a line with those two. And thirdly, if there be no middle-man, let the hindmost standing at A guide the foremost right in a line to B: and after the first chains length, let the hindmost guide the foremost, and the foremost the hindmost: for if the hindmost see the foremost right in a line between him and B, and the foremost see the hindmost right in the line between him and A, then are they both in the right line between A and B. Then, to go forward, let the foreman take all the sticks, and tell them at the beginning at each change, and at the end (for the most common mistake is the losing or mis-telling of a stick) and carry all save one in his left hand, and that one and the chain in his right, and let him go on streight in his station-line, not looking behinde him till he feel the chain check him, then stick down that stick, and away as fast you can run, and as you go shift an other stick into the right hand ready to stick down again. In the mean time the hinder-man, first holding the chain in his right hand at A, let him look the chain be not tangled, and away on till he come to the stick, and then clapping his ring of the chain to the foreside of the stick, let him take it up with the same hand he carrieth the chain, and away after his leader. And when the sticks are all run, and that they are not yet at the end of that station-line, let the fore-man run one chain more, holding still the ring in his hand, and at the end thereof set his toe, there standing still; and let the hinder-man take up the tenth stick, and hold that still in one hand, and the other nine in the other, and deliver the nine to the fore-man, setting his toe to the fore-mans: then let the

fore-man tell the nine, and, if they be right, away; if not, you must measure all that course again, and seek the stick; for you know not which of you lost it; and so going to the end of that station-line, or within so much of the end of it, that you may have libertie to set up the Table, and see to the further end of the next station-line, as you did at A, without any incumbrances; which, if you work by a diagonall scale, may be in any place; but if by a plain scale, you had best to have it at some even poles; and because by *Günther's* chain of an hundred links (which is the best way) you work not by the diagonall scale, by links, but by the foot chain, by the decimall scale, and by poles, and parts of poles. Set that length in your note-book, on the left side of the line, close by the line, and a Bright under A; and on the right side the line write, [*station*]. Then go on still in the said line, till you come to the out-side of the ground, which in pasture will always be beyond the station; but in woods short of it. Set down that length also on the left hand, and the breadth from the station-line at the end thereof, to the hedges you came by on the right; and then draw a line crosse over your book, and so at the end of every other station-line. But you must not forget, that all along as you come you take (as I said before) the breadths from the station-line to the hedge, both at the beginning and ending, and every crook both inward and outward, with their correspondent lengths, and to set them down as afore. Also, if a fair plot in colours be required, it will be needfull to set down the true lengths of each station-line to every mans hedge that shoots upon your plot, beside the ornaments, that you may shew part of their corners, as also in case they are their grounds that employ you in it. And sometime also, if you are to measure two closes being together, and that you would come forth upon that point in the station-line, it will also be needfull to set it down in your note-book, and often save labour marking it with an X.

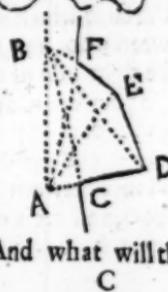
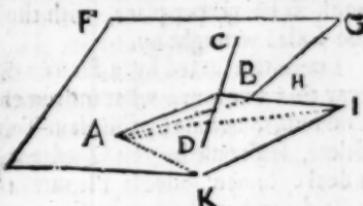
Now if you begin at A, and have two closes lie there together to be measured, then take up your Table there, and having

ving turned the length of the Table to the length of the ground, and proportioned the A of your Table to the A of the ground, set up your sights with the ruler upon the Table, and having screwed it fast, turn them upon the Table, till you see the mark at B. Also see some mark in the close adjoyning on the further side, or a mile beyond : and because I see just there begins a triangle on the right hand, which falls short of the length of the other line, therefore I draw a third station-line from A, reprenting the right-side line of that triangle; so I leave that close till I have made an end of the other, so having drawn my line AB, I go to measuring it by Gunther's chain, and I finde at O of the line A B are five links to the hedge, I enter them as afore. At 200. I crosse a path, which I enter next on the left side; but because there is no crook in the hedge right against it, therefore I take no breadth, but write (path-gap.) At 437. the breadth is 60. I set them down, because here is both a crook, and right against the parting of two closes that shoot upon this: thirdly, it is right against a gap to come out from the further end of the first line in the second close, whereby measuring that and 75. links of another station-line, and setting up the Table twice, that close will be measured, as shall be seen anon: fourthly, it will be a good place to make choise of, to save us some labour in teaching to measure by the chain onely, as shall be shown in it's due place. Hence I go on to 900. there I choose my next station, both because if I do go further, my next station-line, B C, will be incumbered with the hedge, as also I shall have no ground to set the Table on; but here I take no breadth, being the hedge goeth out streight to the end: onely I set down 900 station, and then meASURE streight on to the out-side 907. where the breadth is 8. so I set down 907. on the left hand, and 8 on the right, *out*, that is, without the ground. Then having finished A B, I strike a line crosse the book, and set up my Table again at B, and having made choise of my scale, which I made no use of till this second station, I take off 900. with my compasses from the scale, and set it in that first station-line from A, where I
make:

make a prick, and a little roundle round about it, as also at A. And here I write B; and now that which was forgotten at A, do now: viz. one thing was, to take notice what degree the South-end of the needle bore upon at A: for if there be no er-
rour, it will bear upon that degree quite through the plot, unlesse you remove the paper. And a second thing is, if you are to give in a fair plot in colours, it will be needfull to strike a meridian-line through the plot, unlesse you lay the North-end of the needle upon the *Flowrie-de-lise*, which, in case a fair plot be required, I confess, is the best way: for so you shall draw your plot in the field according to the four windes, whose borders shall be parallel to the edges of the Table.

Now having set up your Table at B, lay your ruler with sights upon the line A B, directly placing your self between the Table and the end of the line, and your face toward A, in such a posture as if you were discharging a musket, and winking with one eye, having both your hands on the two corners of the Table next you, turn the Table till through the sights you see the mark at A: then scrue the Table fast, that it turn no more, and turning your back to the hedge you came by, having propounded to your self another mark to go to at the further side of the ground, by the next hedge-side, as you did at A, lay your ruler close to the prick B, with that end next you, and keeping one point of your compasses, or needle, or scriver, in that prick with your right hand, and the ruler close to it, lay your left hand, being spread, upon it, and turn the further end of it, till through both the sights you see that mark at C, and then holding it stedfast with your left hand draw that station-line B C also. Now if when you were at A, you had set up a mark at C, and another at D, and stroke A C and A D: and thus now also you had here at B struck B D, as well as B C, being the close hath but four angles; you need not have set up your Table any more, no, though you had but struck A D, nor yet have measured any more of it, if you be sure the hedges be all streight, (which is seldome seen in antient inclosure) and that the marks at C
and

and D be set just in the angles. This way, I confess, is something quicker then to go round about, but not so exact: yet this way one Mr. Sheppard of Maldon in Bedfordshire used, who formerly was my Scholar, and who ought Redburn-Parsonage in Hartfordshire, letting every man his tythes at two shillings per acre *communibus annis*. He took me along with him, and each of us a plain-Table, and finding almost all, four-corner'd closes, and streight hedges, we measured but one line in each ground. And indeed, where breadth and lengths are near equal, there will be no great danger; but where there is much odds, they will make such acute angles, that there will be no trust to them, the lines running so one in another, as it is hard to say where they cut; and there fore such as have stufft their books with such whimsies, shall give me leave to laugh at them. Some shew how to measure the depth of a Well (but that is not well) by the plain-table; others teach to measure a piece of ground at two stations, 9 or 10 pole asunder, in the middle of the ground; but there is no trust to any of those ways, that give such acute angles. Let the talk of never so many ways, this one way of going round is *instar omnium*. Whether they take the line A B or C D in this first figure for their station-line, they shall never make good work of it. And what will they do in such a figure as the second?



I con-

I confess, in such a case as the third figure, if there be a trapezium on the out-side of my station-line, such as C D E F; & suppose my ordinarie station-line to be A B, sometimes I use this way. Right against the hedg C D, I set up the Table at A, and having placed the Table in his right situation, I strike these three lines, A D, A E, and A F, and then measure on from A to B, and then set up again, and then again I strike B C, B D, and B E, and never measure any of those six. And after the same manner, if I have a good large triangle on the out-side of my station-line, if my station-line be one side thereof. But in this case, when I come at home, if I determine to keep my note-book and to draw a plot of it 20 or 30 years after; I then draw the like figure in my field-book in its proper place, with the length of each line, and the scale I wrought by.

I once was asked by a famous Mathematician (but I forbear to name him) what instruments I use to measure by? I told him, sometime by the plain-Table, sometime the Theodelite, sometime by the Quadrant, &c. Quoth he, There is a deal of lumber indeed: I'll carry nothing but an high stool a field, and with two sticks a cross I'll stand upon that in the midst of the field, and take the distances to every angle, and I'll measure three acres to your one. I gave him his laying: *risum teneatis amici*, but truly I could not. But let us to our work again. Having now at your station B drawn all the lines you will draw, and drawn a line crofs your field-book, go on to measure the station-line B C, where the breadth at o. is the same which was your distance in your last station-line between 900. the station, and 907 out: viz. 7. set it down on the right-fide of the down-right line under the overthwart line in your book, and o. in the left-fide, then go on at 100 o. at 350 o. at 560 a square stroke into the angle 30. at 563 a station C 568 out. Now having finished this line, take again the distance between B C, 563, upon the same scale you took your 900, and set it on your plot from B. Then if you did not set up at A, or if you did not draw the line D A when

when you were at A, but that there wants two outside-lines to draw still, then set up your Table again at C, and laying your ruler on the line BC, turn the Table till through the sights you see the mark B, which if you do, then see if the South-end of the needle do strike the same degree it did at A and B: if not, there is some fault, which most commonly is in the last line save one, and must be rectified before you go further.

But there is a second way of triall infinitely better, which is this; Having placed CB line right upon B, lay your ruler upon the two pricks C and A, if then through the sights you see A, all is right; if there be a fault, it is commonly in the length of the last station-line save one, which if you came *contra Solem*, and your sights look on the left hand of A, your book is more then your plot, & vice versa. If you have rectified it, set out your next station-line CD, and measure as afore, and make your station, if you can see A, at the very end, and can go free from all impediments: else make it short as afore. And then begin to measure that CD line, having drawn a line cross the book, say at 0, 5, at 200 40, at 200 10, at 656 out, station 12. Where you see, because I need not to set up my Table any more, for there is but one line more to measure, therefore I drive the station-line CD to the very outside; so I take the whole length of the line where my breadth is 12. This length 625 I set on the plot from C to D, where I make a prick within a little circle, and write D: then before I measure the last line DA upon the ground, I measure it first upon the plot, setting one foot of the compasses in D, and the other in A; and then applying that distance to your scale, that will give you the true length of the line DA, before you measure it. So that when you have measured it, if the line on the plot and the line on the ground agree, then all is right; and this we call the true shutting of a plot, which if it agree within a pole, or 20 links, most Surveyours count it well shut: I think it too much, neither do I remember that ever I missed so much in all my life. I once measured a wood called *Horsley-*

wood in Luton-Parish for Judge Crawley, where one Master Lawrence was my Antagonist for St. Robert Napier: he puts me to measure it, and he goes by and takes the angles as I drew, and set them down in his field-book; but seeing that we were forced to make 14 station-lines, and hilly ground too, he offered to wager five shillings, that I should not shut within five pole; I offered to accept it: in regard whereof at the last station, I giving him the distance on the plot, would needs set my Table to try what hopes that gave me, and finding it stroke right upon my A, I then offered to take his wager, to shut within a yard; but I mis'd not a foot. We two had been four times Antagonists for the same men before, one after another, and our greatest difference was never but five pole at a time in sixty or sevnty acres.

An Example.

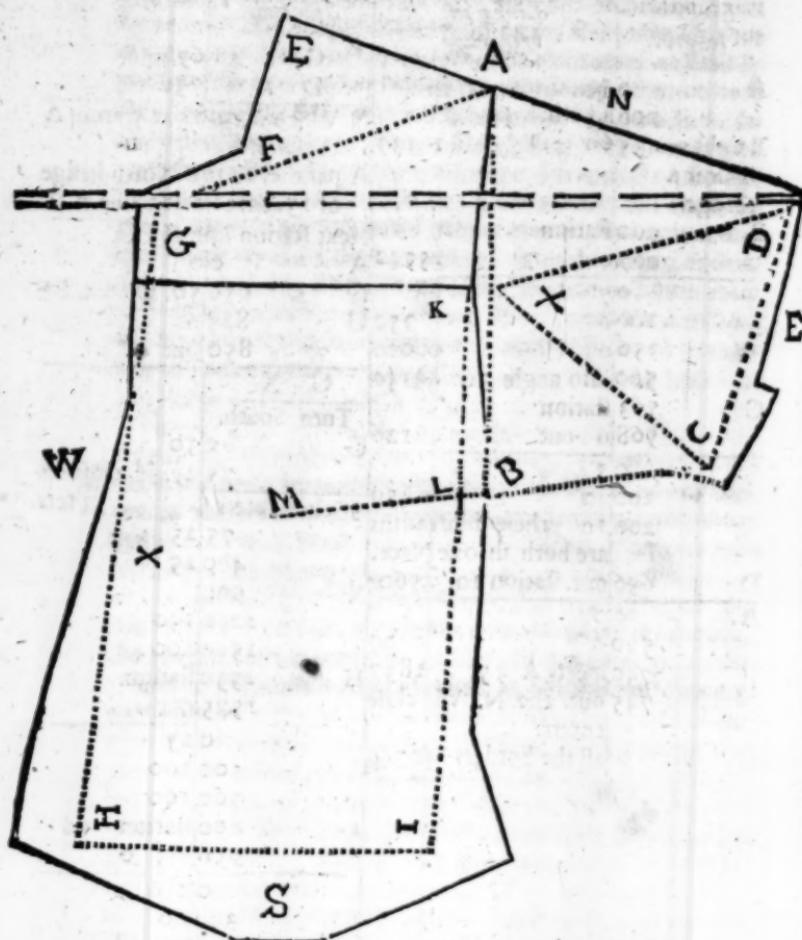
We will give you now an example of the Field-book, and plot of three closes lying together, partly reall, and partly supposed.

Chesterton, Cambridgeshire, June 21. 1656.

Measured by me G. A. three closes, called Church-closes, I for A.B, John Dampier for C.D. upon purchase, S. L. directour. I begin with the East-close at North-West, going contra Solem.

Links

	Links in length.	Links in breadth.	Subtende.	
A	05		C X	674
X right a-	435 60	200 a path.	D X	756
against a hedge.				N. W. close enters at 5 from A Westward.
B	900 station		I 4137	A parallel by the North hedge of 15. next station-line A E.
	907 out 7		15742	Next station-line A FG.
	07		A	00
	100 0	350	F	650 50. stat-lin. F E
	356 0	00000	G	825 60
	560 into angle 30.	3150		850 out 0.
C	563 station		G X	
	568 0 out	120	G	030
	05			75 25. 3 ^d close en-
	200 40	450		ters.
	200 10	these 2 breadths	3 ^d close enters.	75 25
		are both in one place.		400 25
D	656 out. station 10.	4560.	X	900
A	00			1200 140
	5000	0000		1500 200
	740 meets A 15.	1837	H	1550 station.
	745 out. the N. W. close			1575 out.
	enters.			025
	all the borders	40346		300 160
			I	300 160
				800 station 56
				956 out 0
				0156
				300 60
				860 against C
				1340 out 0. against X
				Subtend from out. to X 1090.
				thence to I. 947.
	C 3			



Here you see in this plot, the station-lines, being pricked lines, are not drawn parallel to the hedges, or out-sides of the ground; if we should do so; how many stations should we make

make in stead of that line I L ? Likewise we must make three for C D; yet these are nothing to *Hockley-brook*.

Besides, in working this way my station-lines cut one another more perpendicular, then any other way whatsoever, which is much to be regarded in working by the plain-Table. The onely way to take an acute angle, is with graduated instruments to take the quantitie of the angle, and to calculate it by sines and tangents by the doctrine of triangles; but he that goeth that way to work, may chance to measure ten acres, whilst another doth an hundred. Adde hereto that I can more easily see every crook in the hedge in going round, then any other way.

CHAP. IV.

Of plotting at home, and of severall ways.

They that use to go parallel to the hedges do seldom use any field-book, but plot as they go by the plain-Table, because they suppose themselves to go in the hedges, and therefore allow a parallel from the hedge; but if at any time they cannot go parallel, by reason of houses, waters, bushes, or the like, then they are much troubled, and must of necessity plot as they go, for want of a field-book: whereby they spend much more time abroad, both they & their helpers, then they need, & which they themselves might do in half the while at home; besides that, the least mist drives them out of the field: for though they could measure by the chain onely (which I am sure was never heretofore published by any, but hath ever been thought a thing impossible to plot and prove a plot by: of which (God willing) hereafter;) yet can they no way help themselves for want of a field-book also; the form whereof being already laid down unto you, together with the plot to which it belongeth, being compared together will direct you better then many words; yet because I desire to make all things so plain, that we may be sure you can stick at nothing, we will lead you through one line, and then turn you foot-loose.

First,

First therefore, if you have not yet done in the field, and the weather serves, & your helpers are ready, then take your plot off your Table, and cover it with a new sheet of paper and away into the field, lose no time there, especially if you are far from home; for you may plot & cast at all times at home, but you cannot always measure in the field. But if otherwise, then take your Table from his foot, & the socket from the Table & your plot still upon it, lay your field-book before you, and take your scale and compasses in your hand, and begining at A, both of your book and plot, seeing 5 (which signifies 5 linkes in breadth) is right against A on the right-side of the line, and that you go *contra Solem*, which gives the hedge you go by to B on the right hand; therefore take those 5 with your compasses from off the same scale you laid down your station-line by, and set them from A to the right hand, which although you work by a scale of 8 or 10 in the inch, you cannot take with your compasses, therefore ghuels at them, and then make a prick. Next take with your compasses your next length on your left hand, which is 200, that set in the station-line from A, that is set one foot in A (as you must doe likewise with all the other lengths) and the other where it falls in the said station-line toward B, but because there is no crooke of the hedge, either inward or outward, save only the path, which shewes that there you cross'd the path, therefore onely draw a stroke, or two; if it be broad, cross the station-line. Then take your next length 43 5 and set it likewise in the station-line from A towards B, and for that right against it you have 60 breadth, therefore take 60 and set on the right hand of your station-line, and because I see also (*bedge*) it tells me that a parting hedge of two closes shot right against that 60, therefore I give a little touch with my pen, till I come to set out the rest of it in the other closes. My next-length, being my station 900 B, is set out already. Lastly, because my last length is 907, that is 7 beyond 900, and that the breadth against it is 7 also, therefore take 7 with your compasses, and set it both forward and on the right-side,
and

and thus have you pricked out the hedges against this station-line. Now you must draw lines with your scale and compasses from pricke to pricke, and then with ink: so these parcells between the line and the hedge must be additions to that within the station-lines to this first close; but subtractions from the other where one station-line serves to two closes, as that part of **A B** from **A** to 435 doth both for this and the next.

C H A P. V.

Of calculation or casting up.

The figures or parts to be measured are either squares, oblongs, triangles, or *trapezias*, such as are compounded of an oblong and a triangle. For the square, and the oblong, one rule may serve both, viz. multiply the breadth in the length.

Triangles are of divers sorts, we make use onely of two the rectangle and the *scalenum*, the rectangle without the station-lines, the *scalenum* within. For the rectangle and *trapezium* one rule will serve both, at least those *trapezias* which have two right angles at the station-line. Add the breath at both ends together, take half for the common breadth, & multiply it by the length these breadths and lengths our book will give us. For *scalenums* within the station-lines the way is thus. Look how many angles your station-lines do make, so many triangles will there be save two, by drawing diagonall lines from corner to corner; these diagonalls are fittest for your bases: unless if it be a single triangle, then commonly the longest side. Take the length of your base therefore with your compasses, and apply it to your scale, and what it gives set it down, take also the shorkest distance between the angle opposite to that base and the base it self, apply it also to the scale, and what it gives set down also; now take half the base and all the perpendicular, or half the perpendicular and all the base, and multiply one by the other, so have you the content of that triangle. But commonly where there are more angles then three, one base will serve two triangles, and add both perpendiculars

lars together, and take half of both, and the whole base, or half the base & both them, and multiply; so have you the contents of both triangles.

And thus shall you cast up all your out-borders, just as you found them by the chain; & many times the bases of your triangles also. So that by this way it is impossible to fail much, if any heed be taken; whereas by the common way of plotting without a field-book it is almost impossible, to come near the truth; especially working by so small a scale, as I have known some do, mixing those crooks without with the triangles within: so that they lose wholly the benefit of their measuring by the chain, not taking one line as they measured it, they trust rather to taking up their out-side lines by the scale and compasses, then to their chain: & yet they will confess, that with the scale of 32 in the inch (which I have known a famous Artist use in no great ground) that they cannot distinguish a quarter of a pole. So a quarter mis'd at laying down, and a quarter at taking up, there is half a pole mis'd in the length of each perpendicular, and as much in each base, and these multiplyed, I see not, but a man may passe a ground as near the truth as they. And thus in general.

We will now come to the particular parts, and first of the outsides. We shewed even now how an oblong must be measured by multiplying the breadth by the length; and likewise the rectangle triangle, and *trapezia*, by adding both ends together and taking the half for the mean breadth.

Now therefore in the first close begining at A subtract the first length 5 out of the next, against which you find a breadth viz. 435, there remains the length of that rectangle *trapezium* 435, and for the breadth of it, add the first breadth 5, to the next 60, it makes 65, the half whereof is 32 $\frac{1}{2}$, which multiplied by 435, gives 14137, the content of that *trapezium* to be set against the latter of the two numbers or breadths 60. Where note by the way, that you shall never have any other fraction to multiply by but $\frac{1}{2}$, and for that you must work from the left hand to the right, saying, Half 4 is 2, half 3 is 1, half

half 15 is 7, as here you see.

Then again take your last length 433 out of 907 (for you have no breadth at 900) rests 472, the length of that trapezium, also add your two breadths, 60 and 7 together make 67: (for every middle breadth of each station-line must be twice added, save

435	
32	2
<u>870</u>	
1305	
217	
<u>14137</u>	

where you have two severall breadths fall in one place, as in the line CD, where you have the length 200. twice together) the half of 67 is $33\frac{1}{2}$, by which multiply 472, *facit* 15742 to be set against the latter breadth 7. Then go to the second line BC, where the first length is 100, the common breadth $3\frac{1}{2}$ gives 350, and so go on according as the example gives: then if you add all those primes or square links into one summe, you shall finde it to be 40346, that keep till you have cast up the triangles within the station lines, and likewise all the other slabs. Therefore I draw a diagonall from A to C, which will be the base to both triangles, and half the length is 504. the perpendicular falling from B is 514, that from D is 494, the summe of both is 1008. then these multiplied, the summe of both perpendiculars by half the base, or the whole base by half of them, it gives 508032, which added to the summe of the borders 40346, it makes that first close to give 548378 square links in all. Now to bring these links into acres, you need but onely cut off the five right hand figures, the rest to the left hand are acres, *viz.* five acres: the reason is, there are 25 links in the length of a pole, that squared gives 625 square links in a pole, and that multiplied by 160 (the poles in an acre) gives 100000 links, by which divide your summe of your links, or for the five cyphers cut off five places, the rest are acres; and the five so cut off are the numerator of a fraction of an acre; whose denominator is 100000. So 548378 gives five acres.

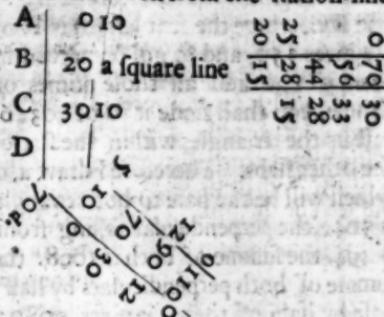
Now to bring these five figures into poles, you may either divide them by 625 the primes in a pole: or else multiply those two of the five next the left-hand always by six, and set them

a place nearer the right-hand, and then add those two which you multiplied, and the two which are under them together, and increasing them so many unites as are fixes in the next two, and you shall have 7 pole and 25 3 links..

If now that when you have cast up a close you have more then half 625 primes remaining; ordinatly it is accounted for a pole: if lesse, then for nothing. But if you have more closes adjoyning, you may reckon it with the next close. Suppose your ground hath the out-side of this form, whose station-line is A D, you may set it down in words thus in your note-book. At A it is 10 to the brook from the station-line o, at B where I have gone 20 pole in the station-line, there is a square line to a crook stroke with the edge of the table, in which at 15 on the left hand is 20, at 28 is 25 on the left hand, and 15 on the right hand; at 44 is 28 on the right hand,

at 56 is 33 on the right hand, at 70 is o, on the left, and 30 on the right hand: then at 30 in the station-line is 10, at which 30 also I strike a station-line forward, which when I have stroke it, I finde the fore-most acute angle by my scale of chords to be 70 degrees, that also I enter in my book: by help whereof and a diagonall line from angle to angle, I can draw the plot of any ground, though many years after, without going to it again.

And after the lame manner you may plot and set down single lands in the common-field, or a close that is narrow and long.



C H A P. VI.

Of measuring a Wood.

THe difference of measuring a wood and pasture is in these two things: First, in pasture you measure on the in-side, but woods on the out-side. Secondly, in pasture all your *trapezia* are to be added to that within the station-lines, unless your station-line be in the close adjoining; but in this to be subtracted.

C H A P. VII.

Of dividing or laying out of ground.

OF this there are three degrees, each more difficult then other. The first is when the length of a ground is given, and a given quantity desired; as if you would lay out two acres of grass in a pasture which is 36 pole long, and you desire the breath: First, I turn my two acres into square links, it is 200000, which I divide by 900. (for 25 times 36 is 900) it gives $224\frac{1}{4}$, the which if you divide by 25, the links in a pole, it gives 8 pole $22\frac{1}{4}$ links in breadth; and this needs no plotting. Or, if you would do by the foot-chain, say two acres is 320 pole, that divided by your length 36, gives 8 pole and $\frac{5}{6}$, which abbreviated is $\frac{4}{9}$: and to know how many half-feet that is, because there are 33 half-feet in a pole, therefore I multiply 33 by 8, *facit* 264, that divide by 9, gives 29 half feet; and $\frac{4}{9}$ or $\frac{1}{3}$, that is, 8 pole, 14 feet, 8 inches.

Secondly, In pasture-ground, suppose a pasture with crooked hedges is equally to be divided between two men. First I plot it and find it 52 acres, 2 roods, 10 pole, that is 26 acres, 1 rood, 5 pole a peice: I ghuels as near as I can to strike a line over the middle of my plor, but measuring one end upon the plot, I finde it wants 264 pole of his due; therefore I measure the length of the dividing line, which I finde to be 56 poles. Now to work by the decimal chain, I multiply 264, my poles

wanting by 625, the square links in a pole, they make 165000 likewise I multiply 56 pole, the length, by 25, the links in a poles length, they make 1400, by which divide 165000, it quotes 117 $\frac{5}{7}$; that is 4 poles 17 $\frac{5}{7}$ links. But by the foot-chain, if you divide 264 by 56, it quotes 4 poles and $\frac{1}{2}$; which to bring into half-feet, multiply the numerator 40 by 33 the $\frac{1}{2}$ feet in a pole, *fasis* 1320, which divide by 56, it gives 23 half-feet and $\frac{1}{2}$ of a half-foot, *in toto* 4 pole 14 feet, 2 inches almost. And so much must you remove your dividing line at both ends: and this may be done as well on the out-side as on the in-side,

Thirdly, To divide a standing wood of 200 or 300 acres, and to drive a streight line from a mark on one side thereof to any mark on the other, though the wood be twenty years growth, and a hill in the midst; A rare secret.

Be sure to plot and measure enough, or more, then you desire to take out of it, and where you intend your dividing-line shall come, there, in your station-line, on the first side set a mark, keeping also good marks at every station, so going on till you be sure you are far enough on the other side also. Then draw your dividing-line by ghuels, keeping one end thereof still upon the mark in your station-line, then measure that part upon the plot, as in the former ground, and add or subtract from your dividing-line as before; save that here you need not remove the further end, if the difference be bot small, but double the breadth at the last. But if you rather think fit to remove both ends, your best way is to do it first on your plot, and make that perfect, and then draw your new line quite through to the station-line on both fides. But there is the mysterie, how shall I give directions how in my absence to drive a streight line cros the wood from a mark in this station-line to a mark in the other on the other side, through standing wood of 20 years growth, and a hill in the midst, as once I laid out 60 acres of Wilsteed-wood being 160 acres between S^r. Thomas Hillersden and S^r. Oliver Luke; and another time in a wood at Hjchin. But not to detain you, If you work

work by the plain-Table, look which side is clearest from im-
pediments, that you may go some 10 or 12 pole outward from
the wood, then let up your Table at that point in your station-
line, that your dividing-line falleth upon, & laying your *index* on the last station-line, turn your Table, till through the
sights you see either your last station before that, if it be not
too near, and having lengthned out your dividing-line as far
as possibly you can, lay your *index* upon that lengthened line,
turn your back to the wood, & sending one before some 10
or 12 pole, let him there move to and fro sidewise as you shall
direct him by looking through the sights, and then at both
your standings drive good stakes, or lay stones, or make holes,
so a line driven through the wood continued streight with
these two will carry you to your first mark in the other side,
if you did not remove that end; or if you did, then to that
mark, where now you must set it: so that look how much you
removed it forward or backward in the plot, so and so much
must you remove it here also; and then set a good mark here
also. But if when you have placed your Table on your station-
line as before, there is but little space left to draw your direct-
ing-line, you may, and indeed far better, lay your *index* all
along your dividing-line and by it direct your man.

C H A P. VIII.

To measure arable-common-field-ground.

IN divers countreys much arable lying in common fields ly-
eth in small parcels, some places an acre, some places half
an acre, and some places a rood, and that so crooked, that
none will desire a plot of such ground; yet, for as much as a
man in time may have his rood grown to half a rood, by his
neighbours plowing of it away, and to find at any time af-
terward, if it be so diminished or not, and in what place: you
shall set it down in your field-book in this manner.

"*Chesterton. East-field in Broad-oake-furlong.* Begin on
"the East-side of the furlong three lands per estimate three
"half

wanting by 625, the square links in a pole, they make 165000 likewise I multiply 56 pole, the length, by 25, the links in a poles length, they make 1400, by which divide 165000, it quotes 117 $\frac{1}{2}$; that is 4 poles 17 $\frac{1}{2}$ links. But by the foot-chain, if you divide 264 by 56, it quotes 4 poles and $\frac{5}{8}$: which to bring into half-feet, multiply the numerator 40 by 33 the $\frac{1}{2}$ feet in a pole, *fasit* 1320, which divide by 56, it gives 28 half-feet and $\frac{1}{2}$ of a half-foot, *in toto* 4 pole, 14 feet, 2 inches almost. And so much must you remove your dividing line at both ends: and this may be done as well on the out-side as on the in-side,

Thirdly, To divide a standing wood of 200 or 300 acres, and to drive a streight line from a mark on one side thereof to any mark on the other, though the wood be twenty years growth, and a hill in the midst; A rare secret.

Be sure to plot and measure enough, or more, then you desire to take out of it, and where you intend your dividing-line shall come, there, in your station-line, on the first side set a mark, keeping also good marks at every station, so going on till you be sure you are far enough on the other side also. Then draw your dividing-line by ghuels, keeping one end thereof still upon the mark in your station-line, then measure that part upon the plot, as in the former ground, and add or subtract from your dividing-line as before; save that here you need not remove the further end, if the difference be but small, but double the breadth at the last. But if you rather think fit to remove both ends, your best way is to do it first on your plot, and make that perfect, and then draw your new line quite through to the station-line on both sides. But there is the mysterie, how shall I give directions how in my absence to drive a streight line crois the wood from a mark in this station-line to a mark in the other on the other side, through standing wood of 20 years growth, and a hill in the midst, as once I laid out 60 acres of *Wilsteed-wood* being 160 acres between S^r. Thomas Hillersden and S^r. Oliver Luke; and another time in a wood at *Hytchin*. But not to detein you, If you work

work by the plain-Table, look which side is clearest from impediments, that you may go some 10 or 12 pole outward from the wood, then set up your Table at that point in your station-line, that your dividing-line falleth upon, & laying your *index* on the last station-line, turn your Table, till through the sights you see either your last station before that, if it be not too near, and having lengthened out your dividing-line as far as possibly you can, lay your *index* upon that lengthened line, turn your back to the wood, & sending one before some 10 or 12 pole, let him there move to and fro sidewise as you shall direct him by looking through the sights, and then at both your standings drive good stakes, or lay stones, or make holes, so a line driven through the wood continued streight with these two will carry you to your first mark in the other side, if you did not remove that end; or if you did, then to that mark, where now you must set it: so that look how much you removed it forward or backward in the plot, so and so much must you remove it here also, and then set a good mark here also. But if when you have placed your Table on your station-line as before, there is but little space left to draw your directing-line, you may, and indeed far better, lay your *index* all along your dividing-line and by it direct your man.

C H A P. VIII.

To measure arable-common-field-ground.

IN divers countreys much arable lying in common fields lyeth in small parcells, some places an acre, some places half an acre, and some places a rood, and that so crooked, that none will desire a plot of such ground; yet, for as much as a man in time may have his rood grown to half a rood, by his neighbours plowing of it away, and to find at any time afterward, if it be so diminished or not, and in what place: you shall set it down in your field-book in this manner,

"*Cheferton. East-field in Broad-oake-furlong.* Begin on
"the East-side of the furlong three lands per estimate three
"half

' half-acres. TA on the East, GD West, coppy of Dame
 " Anne: begin North at 0, 106 at 400 163. at 400 more 101;
 " at 346 ~~one~~ 100, conteining 134500 (that is) one acre 55 pole
 " 125 links. One rood more in the same furlong. R.N. East,
 " J. De West, free of S. John's: begin South at 0, 24. at 400,
 " 27. at 300 more 28, at 244. more ~~one~~ 30. Contens 25526.
 " (that is) one rood, one pole ferd.

Note that in this kind of ground where we say (at 0) we mean two or three pole within the land's end; for there is no certainty in taking the breadth at the very end, for the turning up the plow will get or lose egregiously. Moreover in such ground the best way is, the leader to take all the sticks anew, every time you take a breadth, which had best be not above 400 or 500, especially by the foot-chain, at 16 or 17 pole, as easiest for account, unless the measure or decrease of the land requires otherwise.

C H A P. IX.

Of hilly-ground.

IF a ground have the bottome and top-lines both level, and both sides rising alike, it is to be accounted but as a declining levell, and to be measured as a level ground.

But suppose a ground be level at one end, and both sides, and rising in the middle, and a hill rising along up the middle, as the Lady Farmer's Washbrods-wood in Westoning-Parish in Bedfordshire: or perhaps two hills rising, one towards one side, and another towards the other, and a levell run through between them; this is far more troublesome. For if you shall begin to measure and plot your two levell side-lines, and levell end-line first, and then measure your line at the other end, it will not lie between the two side lines by a great deal. Again, if you should shove out those side-lines, that you might lay that line at the length you measured it, you would drive the hedges into the adjacent grounds, and make them too little as shall appear. But if you are to give a fair plot of a

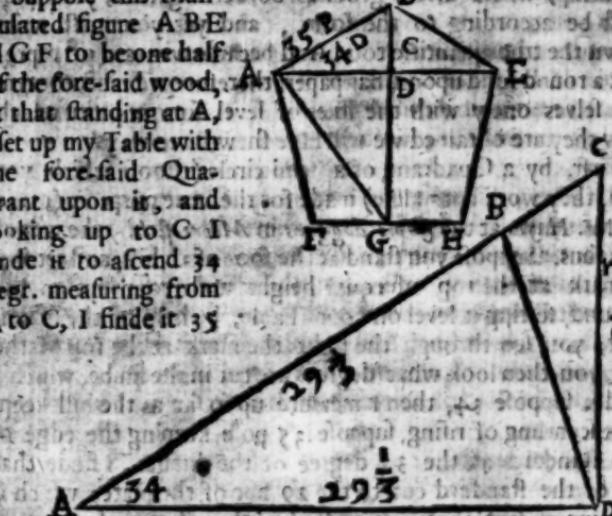
Lord-

Lordship, where divers grounds border together, your plot must be according to the sofir, and yet you must write down the true quanticie too. And because we canot represent a round solid upon a flat paper, therefore we must content our selves onely with the lines of level for our plot: which how they are obtained we will here shew three ways.

First, by a Quadrant, or a semi-circle (choose which you will, they work both alike) made for the same purpose: (made by Mr. Hayes at the *Broz-diggers* in *Moore-field*,) the use of it is thus. Suppose you stand at the foot of an hill, and setting a mark at the top of equal height with your eye to the ground, setting it level on your Table, by help of the plummet, you see through the sights the mark at the top of the hill, you then look what degrees are cut in the limbe, which I finde, suppose 34, then I measure up so far as the hill keeps that scantling of rising, suppose 35 pole, keeping the edge of the standard at the 34 degree of the limbe. I finde that 35 of the standard cut to the 29 line of the plate, which is the line of level that you must plot, though you have gone 35: all these I enter into my field-book. If the hill still rise, you must set again, and as it rises, or falls, so you must alter; so far as it goes level, plot it as level; and what is hilly plot it as hilly. And what is here laid of going up, the same understand of going down.

But never go about to cast up by this plot, though you have shut it never so true: as indeed in such a case it is very ticklish; therefore in this case we may well allow to miss a pole or two in shutting, and yet account it well done too. But for casting it up, this way that it is measured helps not to the finding the true quanticie, though the extending that last line doth come near to the truth, and may indifferently serve in case of letting, because it always is a little under the length, as will easily appear in this diagram.

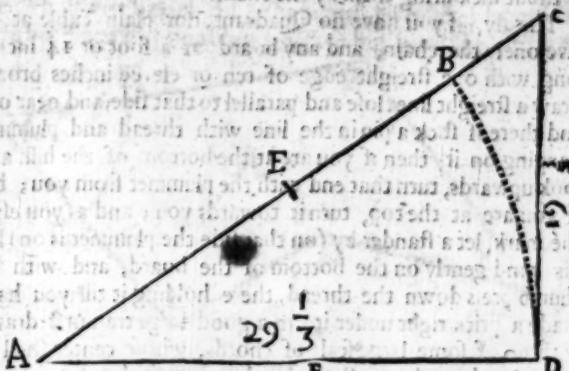
Suppose this triangulated figure A B E D C H G F to be one half of the fore-said wood, & that standing at A & looking up to C I finde it to ascend 34 degt. measuring from A to C, I finde it 35



pole: so then keeping the standard at 34 of the limbe, 35 of the standard gives you both $29 \frac{1}{3}$ for your line of level, and $19 \frac{2}{3}$ both upon the plate at once: viz. A D, the line of level, and C D the perpendicular: now if you add A D, and F G, together, being right angled at G D, and multiply the half thereof by D G, you shall fall so much too short, by how much the multiplication by your D G, is shorter then it ought to be: for in as much as F H is level, and A D so much rising as D C, it must needs follow, that G D riseth up to C, as appears in the other figure. For it is the Hypotenuse to G D, a line of level, and C D a perpendicular. For suppose G D and A C in the first figure to be both of one length, viz. 35 pole a piece, and G D in the first figure, and A D in the second be all one, as if it were the line of level; but now if you lift up A D to A B, it will not reach to C, by the distance of B C in the second, viz. $5 \frac{2}{3}$; for if you subtract $29 \frac{1}{3}$ out of 35 which is A B, there rests B C, viz. $5 \frac{2}{3}$: so that your triangle G A D in the first is less then the triangle A D C in the second,

cond, by the triangle B C D in the second, which comes so near to pole in that triangle. But hereby you see, that having this level plot, and your degrees ascending, and lengths of your lines ascended, you may finde out your perpendiculars: and by them, and the lengths of such lines as shoot upon them, I mean, having the height at both ends, which you shall always take in going round, you may both finde the ascents of those crois lines, and lengths of them also by your Quadrant, without measuring them by the chain. For this instrument having the angle of ascent (whose complement is the angle of descent) and any one of the three sides of a rectangle triangle doth give you both the other, always making the standard the Hypotenuse, and having any two of the sides, it gives both the angles of ascent, and descent.

Secondly, To work this by the limbe of any common Quadrant. Take the angle of ascent as before, and measure the ascending line A C, let the angle be 34, and the line 35, as before; and I desire first the line of level A D: secondly, the perpendicular D C. First, draw the line A C upon the centre A, making the angle A 34 degr, which is done after this manner.



Take 60 from the scale of chords, with that wideness set one foot in A, and with he othertran the arch D B, and take off

34. d. from the same scale of chords, and set it in the said tran from B to D, then draw the line A D, then take $17\frac{1}{2}$ being the half of 35, and set from A to E, and again from B to D, making pricks in E and D. Keep one foot of the compasses at E, and with the same widenesse make a prick at D, and another at C. To Hall A D be your line of level, and D C the perpendicular; both which if you take with your compasses, and apply to your scale of equal parts, you shall finde AD the line of level, to be $29\frac{1}{2}$, and CD $19\frac{1}{3}$, as afore.

If an hill run streight along a ground, if by one side it will be a mere declining level, if through the middle it will be two declining levels, and that line so running along the top will be a line of level, and equal to the line of level under it; therefore if you add both ends together, as you measured them by the chain, and multiply half of them by the length of that line you have the content, if it be of equal height at both ends. But if it be unequal at both ends, though it be a declining level, and have more then three angles, your best way is, to part it in severall triangles, whose Hypotenuses and perpendiculars you may finde by either of the two former ways, without measuring them by the chain.

Thirdly, If you have no Quadrant, nor plain-Table at all save onely the chain, and any board of a foot or 14 inches long with one streight edge of ten or eleven inches broad; draw a streight line close and parallel to that side, and near one end thereof stick a pin in the line with thread and plummet hanging on it; then if you are at the bottom of the hill, and look upwards, turn that end with the plummet from you; but if you are at the top, turn it towards you; and as you espie the mark, let a stander by (on that side the plummet is on) lay his hand gently on the bottom of the board, and with his thumb pres down the thread, there holding it till you have made a prick right under it, in a good large tran first drawn with 60 of some large scale of chords, whose center shall be the hole where the pin sticketh, then take with your compasses the distance between the said prick in the said tran, and the begin-

beginning of the said tran, and apply it to the same scale of chords you drew the tran by, it gives the complement of the angle ascending, *viz.* the degrees of the angle descending. But if you are at the top, and look downward, it gives the complement of the top-angle, and degrees of the bottom ascending. But if you will but erect a perpendicular upon the same center, and take the distance between the prick and it, it gives the contrary.

C H A P. X.

Of reducing a plot from a greater to a lesser.

ALthough there are several ways of performing this, as likewise of a lesser to a greater (whereof there is great use in turning statute-measure into the eighteen-foot pole, &c.) we will lay down onely this one generall rule.

First, beginning at any one angle, as at A, and so go round in order from angle to line, and from line to angle: Suppose the plot (A) to make another, *viz.* B but a quarter so big: yet like it both in form and content, onely it is drawn with a scale of half that bigness; for $\frac{1}{2}$ the bigness gives but $\frac{1}{4}$, because $\frac{1}{2}$ of $\frac{1}{2}$ is but $\frac{1}{4}$ and so $\frac{1}{2}$ make but $\frac{1}{2}$ part so big, because $\frac{1}{2}$ of $\frac{1}{2}$ is $\frac{1}{4}$.



First draw the line A B of the figure B, representing the line A B of the figure A, regard not though it be as long as it or longer: at the end thereof make a prick for a center, and write,

or suppose (A) to be there written, then open your compasses to any widenes, as to F in the figure (A) and tran F G, with the same widenes do the like in the figure B, take F G in the Figure A, and set it in the figure B, then take either $\frac{1}{2}$ the line A B of the figure A, and set it the same way in the line A B in the figure B: or else take half the length thereof from the same scale the figure A was drawn by, do the like by the angle B, as you did by the angle A, and likewise by the line BC and so angle after angle, and line after line, till you have done. And thus may you make

a plot bigger or lesser, as you please, onely by changing the scale, yet the area, or content, will be the same, as before. But if the borders of your plot be very crooked, it wil be needfull to draw streight lines, either within or without both the plots, like station-lines in both the old plot and new, and to take the crooks from those, just as you did in the field; if you will have it equall in bigness to the other, and that your streight lines be of like length in both, then set the same wideness in your new plot from your station-lines, each against its proper length: but if your new be bigger or lesser, then apply those distances to your scale, and take $\frac{1}{2}$ or $\frac{1}{3}$ or more or less, according to the proportion of your two plots.

Or Secondly, If you desire a plot equall to another, you may oyle a paper, drie it well, then put it over the other plot, that it stir not, through which you may see the lines on the neather plot, then draw them with your pen on the oyed paper, then take it off to prick it, then pounce a new paper & draw it.

Or Thirdly, Having drawn a line representing A B in your new plot, take the line A B off the old, either all, or $\frac{1}{2}$ or according to your desired proportion, & set it on the new. Also take the proportion of the line (A E) and set one foot in (A) and tran where you think (E) will fall in your new.

Take



Take also the like proportion of the distance of (B E) and set in the said tran, and so you have (E), the same 2 distances will set out (D) also (D and B) will set out (C) and so you have all your angles, then draw their lines, and you have your plot desired.

CHAP. XI.

Of measuring pasture-ground by the chain only, and that as speedily and exactly, as with any instrument whatsoever, and with less help though in misty weather, & to plot, save, and prove, the plot thereby also.

About the midst of one of your longest station-lines, and some known length in the same (as at X in the first or third close, chap 3^d pag. 22) set up a mark, and mark it in your book, both with its proper length & letter, then having measured round about the ground on the inside, or at least all but the last side: if you have more then three angles, instead of measuring it from angle to angle: viz in the first close, from A to C, or from B to D, you shall measure from C to X, and from X to D, so making a triangle the more then otherwise, which two subtendents will easilie be run whilst you can set up the Table once, so you shall need less help by one to carry your Table, for that is wholly one bodies work: and these two subtendents must be set down at the latter end of your notes of that close in your field-book. Then if you measure the last side A D having plotted the rest, if that A D on the ground, and A D on the plot agree, all is right, neither ever need you divide any more lines then one in the whole ground or close throughout, so that at least none of the station lines strike outward, for then it must be accounted as another close, so much of it till the last line that strook inward being continued streight out do meet with the other plot again. See more chap. third.

Now to plot such a ground measured by the chain onely, suppose it be the said first close, (chap third) first I draw the line:

line A X B, making a mark at X, and another at B; secondly you must either take the subtendent X C, setting one foot of the compasses in X, & tranning where you think C will fall; or else take the station-line B C with your compasses and set one foot in B stan at C and then take the other of these two last lines, viz. X C, setting one foot on its proper mark X, and with the other make a prick in the said tran, and so have you placed C in his right place, then draw the line B C, next take C D with your compasses, set one foot in C, and tran where you think D will fall, then take the subtendent D X, set one foot in X and make a prick in the said tran, and that sets out D, then draw the line C D, and because D is your last station, and that A and D are both set out already; therefore, draw also the line A D, now if A D on the plot and A D in your book agree, then all is right, else not. So that in this kinde of plotting there are onely these three posititres. First, draw a station-line; secondly, tran with a subtendent; thirdly, prick with the next station line.

Nevertheless in great larg plots, it will be needfull to use a good larg pair of compasses, because you must take the whole length of your lines with them. In which case a pair of beam-compasses, with a beam of deal, willow, or sallow, or some such lost wood, is best of all, of 17 or 18 inches long, with a piece of an awl-point near one end, and a sliding button to be moved pretty and stily up and down, and to be stayed with a screw pin, or wedge at any distance, with an other short point in the end thereof.

Now we will shew you how to continue your plot out of one ground into another; that so you may lay all the grounds of a Lordship together in one entire plot by the chain onely, and that we will do by severall rules; for the understanding thereof we will refer you to the plot in the latter end of the third chapter, as also in the end of the book. The knowledge whereof consisteth in four rules in the obtaining the first station line in the close which you go unto. As for example.

First, Suppose I would go out of the first close at A, and would

would plot the station-line A G; now because in plotting these kinds of grounds you must always reduce all into triangles, therefore standing at A you may measure two chains length in the line A F, or A G, likewise two chains back-ward from A towards B, in the line A B in the first close; then measure the distance between those two lengths, and plot them after this manner: First, your best way is (though you have measured but two chains length a piece, yet) in stead of two, take the double; if the station-lines belong, you may triple that distance, setting one foot in A, and extending the other towards B; there make a prick in that line, and tran from thence with that wideness where you think the line A F, or A G will fall: then look what the distance was between the two lines at the end of your two chains a piece; if doubled before, then double again that distance upon your scale, and set it in the tran from the line A B in the first close to the line A F in the second, and draw the line A F G through that prick *ad infinitum*. Thus have you got a line in the second close, by help of a part of the line A B, which in this kinde you must always take, *viz.* that station-line, whereof the whole or part belongs to both the closes. But because in this case you must always mete through the hedge, from the two chains of one close to the two chains of the other: therefore to avoid the trouble of cutting a hole through the hedge, if there be ever a gap, gate, or stile near unto those lengths, you may take more or less of those two lines as you please: now because here is a gap at two chains and an half from A, in the line A B, you may measure two chains and an half of either of them, or two and an half in that, and three in the other, as you please; and measure the distance upon the ground between those two pricks: then you may double all three distances upon your scale, as afore, and set out the proper distances between those two pricks, as afore, and then draw your line A G upon your plot in the second close.

But, Thirdly, because we have measured the distance between A and X in the first line, which is one side of the triangle

gle of that second close, and likewise have measured from A to G on the second side, and have a gap also at X; therefore if you measure G X, you will have all the sides of that great triangle which you may use as afore said: First, you have the line A X already placed. Secondly, take the length of A G, with your compasses upon your scale, and with that widenels, set one foot in A, and tran where you think G will fall. Do likewise with the line G X, taken also upon your scale, set one foot at X, and the other is the foresaid tran, and there is your center G.

And after the same manner may you go out of that close, into the great close from G, by help of the line A G. Now having the line A F, or A G, you may easily set out the triangle A F E, as you did A X G. Likewise you set out the triangle that is between the the line X G and the hedge, between the two closes only by the distance of G to the entrance of the great close:

A second way of going out of one close into another is, when I have a station near the middle of a station-line, and that there I would go into another close. For example :

Suppose I would go out of the great close into the first close, right against the station-line B C in the first from L in the station-line of K; then when you come right against B C, the station line, lengthen that line B C back-ward into the great close from L to M two chains length; measure also two chains lengths in the station-line L K; and measure two chains lengths from L to I back again; and measure the distance between two chains of the one, and two chains of the other, and that gives you the quantitie of the angle K B C. Then from the line L K; you may take from your scale four chains length, and you may tran from the line K L, towards the line L C, or B C, with one foot set in L, and double the distance of the two pricks in the other close, and take that with your compasses, and set from the line L K, to the L C, and where it falls draw the line L C ad infinitum. After the same manner might you have drawn a line by the South-side of the hedge

by

by B C or L C. Also so might you at X in the first close have gone either into the great close, or into the little close, by drawing a station-line on which side of the hedge you will.

A third way is by continuation of such a station-line as shoots upon the corner of a close; and thus suppose you would go out of the great close into the little close at K; if you had but continued your line L K to A; and this is the easiest way of all.

A fourth way, If on the West-side of the hedge A K there were a spinny wood of two or three pole broad all along by the sides thereof, and that you desire to go out of the first close into that little close, but there is no gap, save only you can strike a squire-line from the station-line A B, at either end of A & K; then may you both at A and at X erect a perpendicular into the first close ward; and then may you continue those two perpendiculars, so far as you shall need them, till you are free from the spinny, and may draw a line from one to the other by the spinny side, and truly plotting out either perpendicular from the last station-line.

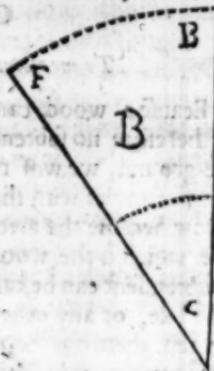
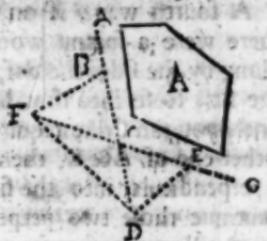
CHAP. XII.

To measure a wood by the chain only.

Because a wood cannot be measured on the inside; and therefore no subtendents can be taken, as they may in pasture-ground, we will therefore endeavour how to do it by taking of angles with the chain.

Now because the meeting of the station-lines gives but one angle, which is the wood corner, or at least so near to it, that no subtendent can be taken from any part of one of those lines to the like, or any other part of the other, yet if you cross or lengthen them out beyond their meeting one or two chains length a piece, you shall then have three angles more, whereof the opposite angle to the wood angle will be the same with the wood angle, and either of the other will be the complement of it to 180 degrees; so that if you can but take one short

line in any of those three angles, you are well enough as suppose A to be a wood, and at the angle C, I had two station-lines met, viz. A C, and C G, I continue A C forward to D one chaines length, or else set C G backwards to E a chains length, and likewise set back A C to B one chain of 100 links: now suppose I find F B or D E to be 60: now for that C B and C F are each of them 100 and F B 60: I first plot them, first striking a line, then I take 100 from some scale of equal parts, as C B in the figure B. And because C B and C F are equal, therefore I set one foot in C, and tran F B, also from B to F I set 60 of the same equal parts, then draw the line F C through C, and it gives the station-line C G; Or more easilie, if you draw out the line A C unto D, and make C D and C E 100. a piece, finding D E to be 60 then may you take 100 of any scale of equal parts & tran D E, then set 60 of the same parts in the said tran from D toward E, make there a prick & draw the line C G through E. But if by reason of impediments you can neither measure D E nor F B at 100 a piece, you may tran C B 200, and F C 100, or either of them what you will, to that you plot them accordingly; as if C E be 130, C D 100 and D E 50: then first set out C D 100 in the line C D, secondly take C E 130, set one foot in C and tran with the other, and thirdly take D E 50, set one foot in D, and with the other make a prick in the tran and draw the line from C through E as afore. Now if through impediments by none of the foresaid ways you can measure neither of the foresaid angles, then see what you can do to the



the angle F C D, or the angle opposite to the angle of the wood : for this therefore you must both lengthen A' C to D forward, & C G to F backward, each of them 100 or more from C ; then measure the distance D F, and apply it to your scale of equal parts, and what it gives set down in your notes book, as likewise you must do all the other lengths. Then supposing C D, and C F to be 100 a piece, I take 100 and let one foot in C, and tran from E; then suppose I had found D F 160. I take therefore 160, and set from D in the said tran, and it reacheth to F; therefore draw F *ad infinitum*, and it gives the next station-line C G.

But in all this that hitherto we have spoken of measuring by the chain onely, we would have you to understand, that we have onely spoken spoken of measuring and plotting of the station-lines: for as for measuring, casting up, and plotting of the out-sides, that is the same as before, setting as well to this as to the Table.

And as for measuring hilly-ground, we have shewed before in *chap. 9.* that also may be measured by the chain alone, save onely any sorry board with one streight edge; & it matters not greatly whether it have a streight edge or no. If in measuring the out-sides you go upon a station-line, as in the line A F G of the second close, (*chap. 3.*) from which you desire to strike a perpendicular into an angle: First, ghuels at the place, so near as you can, where it will fall; there set one of your counting-sticks, set another 80 links backwards, directly in the station-line; another at 60 from the first stick into the angle; then let one hold one end of the chain at the stick that was set backward, and the other at the stick set in the angle-line; if they two meet just at the chains end, (I mean Gunther's chain of 100 links) then is it a true perpendicular into the angle; if it fall short, you are not far enough; if gone, then you are too far.

If a ground be very large or bushy, you may measure it on the out-side like a wood; or measuring a chains length or two of each station-line, and their subtendent on the inside from the angle.

Thus have we shewed you how to measure all manner of ground by the chain onely, for which I expect as much thanks at the instrument-makers hands, as *Culpepper* at the Colledge of Physitians. And indeed I was determined to have published it above fourty years agone, had not Mr. *Allen* and Mr. *Thomson* dissuaded me from it, upon this reason, That if ignorant people see the most famous Artists go so to work, they will be ready to judge, that he that goes with a plain pair of poles, and a square board, to set out a square withall, is a better workman then he. And indeed, I cannot deny but that they judge according to their tools which they see, rather then according to their skill they see not.

Whereupon I have forborn till now, considering I am even dropping into my grave, and considering that my Saviour would not cease casting out devils, because he was thought to do it through *Beelzebub*; no more will I longer forbear this, it being so lawfull, and honest, and beneficall to a Commonwealth. And truly had I regarded mens sayings I must have given over surveying long ago, or else to give over profession, for that I was judged (by no small fools) to work by the devil, for that I could tell a distance before I measured it.

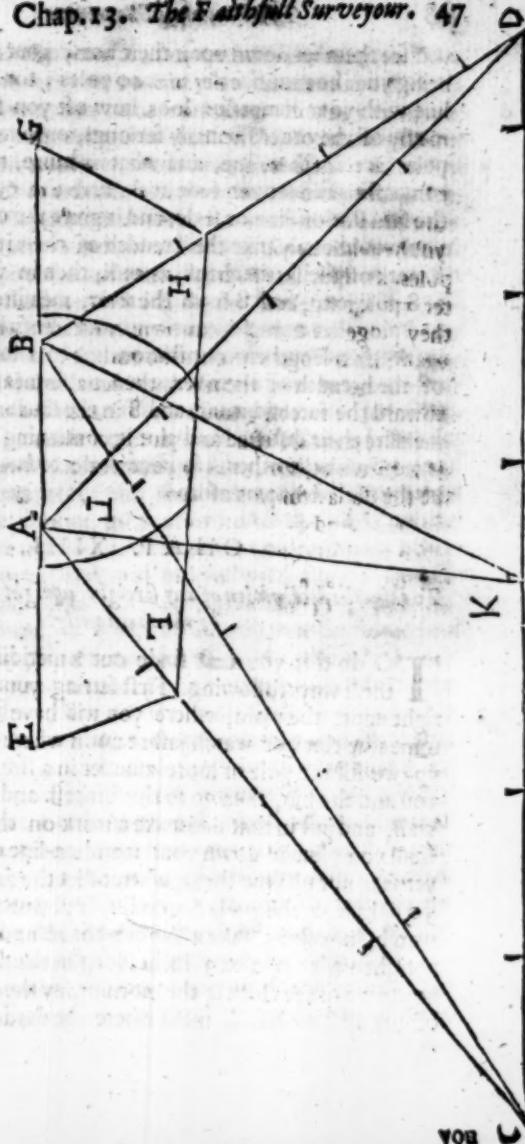
CHAP. XIIII.

Of taking distances by the chain onely.

ALthough we have shown the measuring of all manner of land by the chain, yet since we are speaking of the use of it, I hope you will not think your time ill-spent to read a lesson or two more that will be effected by it.

Let there be two forts C and D of a good distance asunder, beyond a river a mile or two broad, to tell the just distance how far they are asunder, how far each is from A, and each from B, and the breadth of the river: First, I draw the line A B 40 pole, a tenth part (at least) of the greatest distance; let it run parallel, but freight, by the river, 9 or 10 pole off; then from A I set out both backward from A to E directly backward in the station-line six pole, and six from A to F in A C line

line, then E and F are four pole alunder. Also I measure from B to H 6 a piece, and 6 between them also; and from A toward B and D 6 pieces, and they are $4\frac{1}{4}$ alunder, and from B toward A and C 6 a piece, they will be $3\frac{1}{2}$ alunder: but it is best to draw your station-line with a very small scale; but set out your angles with a very great one; then draw A D and B D, till they meet at D, likewise A C and B C, till they meet at C, and a right line from C to D, for the distance of the two forts: and another from B to K for the breadth of the river, so shall you finde all your desired distances of



you

you see them set down upon their lines; your station-line A B, being your common scale, *viz.* 40 poles: for if you take that line with your compasses, look how oft you finde that length in any of the other, so many furlongs, or so many times fourty poles are in that line, and what is more, take it with your compasses; and set one foot at A, and the other forward in the said station-line or scale, and it gives the odd poles. But if you would onely take the breadth of the river K L, observe a mark on the farther bank, as at K; then in your station-line at 8 pole long, and 8 from the river, measure their distance, and plot that triangle, continue your cross-line toward your mark; then lengthen your station-line to a fourth or fifth part of the breadth of the river; thence also measure 8 pole right toward the foresaid mark, and 8 in the station-line, backward; measure their distance and plot it, continuing the mark-line till it meet with the other: so your scale to both the other will be the station-line, as afore.

C H A P. XIII.

To take the declination of any streight upright wall for Dialling by the chain onely.

TO do this you must finde out a meridian-line by any of these ways following. First setting your back to the wall right under the plain, where you will have the diall, look by some true clock or watch just at noon where the sun is, and set up two sticks a pole or more asunder in a streight line between you and the sun, then go to the furthest and look back to the wall, and just in that line make a mark on the wall: for there shall you plumm down your meridian-line of your dial. But yet take not up your sticks, whereof let the furthest of them be 50 links from the wall. Secondly, if you neither have help of watch, nor clock, take a smooth board and lay it level, stick upright a wier of 2 or 3 inches long in the midst of it, and about nine of the clock in the morning lay the board at the foot of the wall aforesaid, mark where the shadow of the top of

the

the wier falleth, there make a prick: then take out your wier, and set one foot of your compasses in that center, and open the other to the former prick, and there draw a circle, and then set up your wier upright as it stood before, neither deeper nor shallower then before, you may apply a squire to it, to see it stand upright, or measure with your compasses from the circle to the top of the wier, if it be alike all 4 ways. If it be right, set up two sticks right in a line between it and the Sun as afore. Then again about three a clock in the afternoon watch where the Suns shaddow falls just on the same circle again, and then set up two other sticks, so that they may meet in the same centre, divide the space between the two furthest sticks into two equal parts, and mark that for your meridian-line. But lest the Sun shoule not shine when it comes to that circle, you may make severall circles upon the board, and stick up marks where the Sun comes at them forenoon and afternoon. If both these ways fail, this third way is better then either of them. In the evening go Southward of the place, where you would haue your diall, three or four pole, turn your face Northward, moving Eastward or Westward till you see the North-pole and the place where you will have the meridian of your diall both in a line, which by looking over the house you may the better do, if you get one to hold a pole aslope with a line tyed to the end thereof and a plummet to it. If now the line, the meridian-place on the wall, and the North-pole are all in a line, you are right, there stick up a stick till morning, another right behinde it; for just there is your meridian-line.

Now to know the pole you may easily ghuess at it near enough, for it is a point in the heavens in a right line between the hinder horse of Charles-wain called Alliot and the polar-star, so far off from the pole-star, as the pole-star is from the next star to it: so that if Alliot be just beyond the polar star then is the polar-star full North, & *è contra*.

A fourth way is this; in some plain place near hand where you may see both ways set a mark, go South two or three pole,

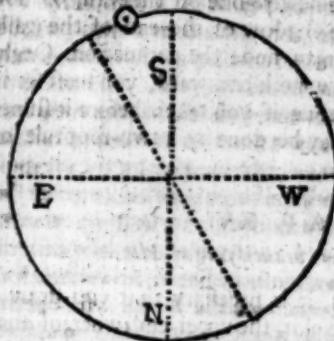
pole; then move Eastward or Westward till you see the pole-star right beyond the first staff, there set another, or rather pitch two good stones, like grave stones in Church-yards: for so they will not only serve for this busines, but also give the hour of the night to a minute by knowing the right ascencion of the Sun and stars.

The use we make of it here is double, first it helps us to set out the meridian-line every where near hand; for if standing here at the North stone you see the Sun right over a stick or pole holden at the South, you run presently & set your back against the wall where you would have your diall, and set up two sticks between the Sun and you, you have a meridian-line desired.

Now having gotten this meridian-line: to finde the acute angle that this meridian makes with the wall; first, measure with your chain one chain, or half a chain in this meridian, and as much by the wall-side, and their distance for a third side, and plot it; then finde the quantitie of the angle of intersection of the meridian and wall-line by the scale of chords, the complement thereof is the declination of the wall. Suppose the line A B to be a meridian-line, and A C to be the wall-line, in either of which I measure from A to C, and from A to B 50 links, and I finde the distance of C B to be $24\frac{1}{2}$, this I plot as afore is shown. Then to finde how many degrees the angle C A B makes, take 60 from some scale of chords, and set one foot in A, and tran D E: then take D E with your compasses, and apply to your scale of chords, and it gives the angle of the wall and meridian D A E, or C A B, which is all one, to be 30 degrees, and the complement thereof 60 is the declination of the wall; which if were taken in the morning, it is a South-west diall, declining West-ward 60 degrees: (for always the distance of the wall-



line to the East or West-line is the declination of the wall;) if the Sun shone on it at noon, it is a South dial; if it shone longer on it in the afternoon, then in the forenoon, it is a South-west, & *contra.*



the Sun-line; measure the distance of those two fifties; and plot it, then take 60 off your scale of chords, and do as in the last rule.

*Having the Azumeth, to finde the angle of the wall
and Sun by help of the last figure.*

Sometime you are in such a place where you cannot set out a meridian-line, yet you may always set out an Azumeth, or Sun-line, which elsewhere I call the angle of the wall and Sun. Now finding your Azumeth, as in the last rule, come presently from thence, not staying to cast it up or plot it; but presently measure 50 by the wall, and 50 in the Sun-line, and their distance, and then plot both the triangles, and finde the degrees of both angles at the centre, as afore; so have you both the Suns Azumeth, and the angle of the wall and Sun. Then making a circle with two crois diameters, first set out your Azumeth from the South; if it was taken in the morning, then on the East; if in the after-noon, on the West. Then always reckon backward the angle of the wall and Sun in the course of the Sun; and from thence draw a line through the centre representing the wall-line, (as in the last diagram) the distance be-

tween that and the East and West line in the circle is the declination of the wall desired.

And although the Sun be newly gone off the wall, or not yet come on, by help of the shadow of the end of the wall, and these former helps you may finde the declination. Onely in stead of setting your Azumeth backward, you must set it forward in the course of the Sun, if you take it before it shines on the wall. And all this may be done by a two-foot rule or yard, or a boyes cat-stick.

C H A P. XV.

Of colouring and beautifying of plots.

IN beautifying of plots, it is necessary that you draw a square round about the plot, the upper-end whereof shall represent the North-side, the nether line the South; the right-side line the East: but you must help your self to these by taking a meridian-line first in the field, and drawing a meridian-line through the first plot.

Secondly, Examine your former plot, how many chains or poles your plot reacheth from North to South, and from East to West, and thereby make choise of such a scale, that you may lay the whole Lordship within the said square, according to the Northing, and Southing, and distance. Or else you may draw your plot, first, by what scale you will, and then draw the square afterward.

Thirdly, Fill the out-borders between the square and the demeans, at least such as border next to the demeans, with the bordering hedges, and names or owners names of the grounds.

Fourthly, Whatsoever you write, write it from West to East: unless it be the proper name of some river, or high-way, or such like. For if the North be upward, the West will be on the left hand.

Fifthly, Describe all houses, ways, rivers, Churches, windmills, arbours, great lone-trees, gates, stiles, &c. that fall within your plot, as also the Lordship-house, with other edifices.

ees in a corner by it self, and the Lords coat in another corner: the house being drawn in perspective.

Sixthly, Describe at the bottom the scale that you drew it by, adorning it with compasses, ovals, squares, and compartments, &c.

Seventhly, Having drawn all your severall grounds, and distinguished them with their hedges, it will not be amiss first to pounce over the paper or parchment with some Spanish grain, and burnt Allome, and a double quantite of pounced rosen, both finely searced, and lightly pumiced; thereby to preserve the paper or parchment from through-piercing with the colours.

Then lay on your colours in manner following, being first ground and bound with gum-water very thin and bodiles. Arable for corn you may wash with pale straw-colour made of yellow-ocre and white-lead. For meadows take pink and verdigrease in a light green. Pasture in a deep green of pink, azure, and smalts. Fens a deep green, as also heaths of yellow and indico. Trees a fadder green of white-lead and verdigrease. For mud-walls and ways mix white-lead, and rust of iron, or with ocres brown of Spain: for white-stone take umber and white: water or glas may be shown with indico and azure, or black-lead: for seas, a greenish sky-colour of indico, azure, smalts, white-lead, and verdigrease.

CHAP. XVI.

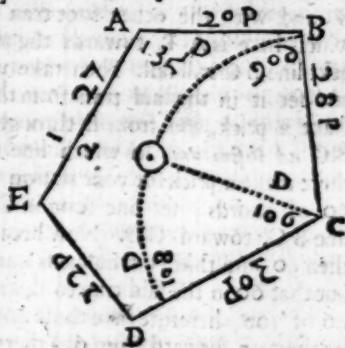
*To measure all manner of ground by the Pandron,
or any other graduated Instrument.*

THe Pandron is an instrument compounded of, First, an ordinary foot, with three legs for a plain Table. Secondly, a Table and folding-rulers like it, save that it is a true square. Thirdly, the box and needle. Fourthly, it hath on one corner a centre, in which is a screw-pin, on which a moveable ruler with sights turneth. Fifthly, in the two out-sides furthest from the centre is drawn the Quadrat for terrestrial altitudes and

distances. Sixthly, next to it is the limbe of the Quadrant, both for celestial and terrestrial altitudes and distances, whether upright, flat, or aslope. Seventhly, *Gunner's Quadrant* for your own latitude for hours both of night and day, and Azimuths, and divers other problems. Eighthly, *Fale's Quadrant* for Planetary hours. Ninthly, a circle and scale for finding the declination of a plain. Tenthly, a neck of 14 or 15 inches long, to put on the top of the staff, the Table being taken off, with a pin on the side to hang the Table on, to take all manner of altitudes and distances aslope. Eleventhly, a beam of 6 or 7 foot long about two inches square of deal, and a trough on the top, gouged all along half an inch deep, to fill with water for a water-level, having a sight at each end, having a lath crossing the beam in the middle above and below 6 foot long, fastened with screw-pins and brackets above and below, with an hole in the bottom of the middle of the beam, in stead of a socket to stand on top of the three-foot staff. So that there is nothing that all or any observing Instruments can do; but this doth it. By this you measure land as by the plain-Table, then if the weather be moist, or in hilly ground, you may uncover the Table, and work by the Quadrant, whereby you may save the charge of hill-ground sights, which are as costly as all the rest of the Instruments. Besides which if you know how to work by the Quadrant, you cannot be ignorant of working by the Theodelete or semicircles, the difference being onely this, that they take onely at once, which if it be above 90 degrees, by the Quadrant you first take some part of it, and then the rest of it afterward, yet all at the same station, and then plot it by your scale of chords. Indeed by the Circumferentor you take all the angles by observing the cutting of the South-end of the needle, and then either plot the angles by a protractor, and the lines by a scale of equal parts, or else you may plot the angles either by your scale of chords, or by the Circumferentor it self, both which I hold better ways then the first. So that there being nothing desirable in an observing instrument, but this giveth it, it so pleased

pleased Mr. Hender Roberts, (the Lord Roberts youngest son, a Gentleman every way fitted with a genius for the Mathe-maticks, whom I cannot name without honour,) who had the first of them to give it the name of *Mr. Hender Roberts, omne de-num*. So that in shewing the use of it as it is a Quadrant, we shall with the same labour shew the use of all graduated In-struments in measuring of land; and as for working by it as by the plain-Table, we refer you to the ten first chapters of this book. Now therefore for working by the Quadrant, (yet herein we will speak of nothing but what is within the statio-nary-lines, contenting our selves for the rest with that which hath been spoken before in the use of the plain-Table,) all the difference consists in three things: first, the taking of the angles: secondly, in keeping the field-book: thirdly, in plot-ting.

First, For taking of the angles, you need not set up your Quadrant oftner then you did the plain-Table: there-fore suppose this figure A B C D E to be a plot of ground to be measu-red on the inside: I be-gin at A, not setting up the Instrument, but finde A B to be 20 pole, that I set down in my note-book, besides the breadths from the statio-nary-lines, which I omit here as sufficiently spo-ken of before. Then be-ing come to B, there I set up the Quadrant, and finde it just 90 degrees, I set down B 90 degrees, so that all the lengths are measured by poles or links, and all the angles by degrees: then I measure B C, and finde it 28, and set it down: now I come to C, I lay the sharp edge of the rule to the line of the Quadrant, where the degrees begin, and then screw down the



AB. 20. p. the sights for stirring, but turn the Quadrant till through the
 B. 90. d. sights you see a mark at B, (as when you were at B you saw
 BC. 28. p. at A.) Now seeing that mark at B screw the socket pin, that
 C. 106. d. the Quadrant turns not, but turn your sights to D: but I can-
 D. 108. d. not, for they fall besides the board; but I have espied a mark
 DE. 22. p. at O near the middle of the ground, viz. a tree, I turn my
 E. 101. d. sights to that, and see the sharp edge of the rule cut 60 de-
 EA. 27. $\frac{1}{2}$. p. grees, that I keep in minde, then I lay the sharp edge of the
 rule again on the beginning of degrees, and turn the Quan-
 drant till I see the same tree again through the sights, then stir
 not the Table, but stir the sights till you see D through them:
 then looking by the edge of the ruler, I finde it cuts at 46,
 which added to 60 gives the whole angle C 106: and so of
 the rest.

*To plot a plot
 taken by gra-
 duated In-
 struments.*

Now for your plotting it, first draw the line A B, set out
 20 of your scale of equal parts upon it, then take always 60
 off your scale of chords, set one foot at the end of your 20 in
 B, and with the other foot tran always from the last line,
 which here is A B, towards the place where you think your
 next line B C will fall. Then take your angle B which is 60,
 and set it in the said tran from the line A B forward, there
 make a prick, and from B through that prick draw the line
 B C ad infinitum. In which line set out 28 of equal parts,
 there make a prick for your station C. Then take again your
 60 of chords, set one foot in C, and tran from the last
 line B C, toward CD. Now because your angle C is more
 than 90, and that your compas tran at 60, therefore first set
 out that 60 in the said tran to B, and because there wants yet
 46 of 106, therefore take those 46 with your compasses, and
 set them on forward from 60, there make a prick, and draw
 your line CD through it, and so of the rest. So that there are
 but these things: first, draw a station-line: secondly, tran
 your angle with 60 of chords: thirdly prick out the degrees
 of that angle.

C H A P. XVII.

In measuring by graduated Instruments, to know if your plot will shut, or no.

Because in working by graduated Instruments, you always plot at home, but never in the field; and that if any thing be mistaken in the field (as oft it comes to pass to be so) then will not your plot shut at home: therefore either you must look to your needle at every plantation, or else you must measure all the angles, which by the plain-Table you need not do: therefore with such Instruments the needle is more needfull, than with the plain-Table; and yet the *Circumferentor* will hardly help you herein neither, though you work all by the needle, unless you work by taking angles by it, which is the flower way. Now having measured all the angles, if on the inside of a ground, because all the three angles of a right line triangle are equall to two right angles, or 180 degrees, and that there are so many triangles save two as are angles; therefore if you reckon so many angles save two, for each of them 180, and finde that and the quantities of all your angles to agree, there is great hope your plot will shut, else not. As if there be a triangle, they must all make 180; if a quadrangle, 360; if a pentangle, 540; an hexangle 720; a septangle 800; an octangle 950; but if you measure on the out side, as a wood, then every outward angle is the complement to 360 of its inner angle; therefore to take all those complements, is your best way both to prove and plot it by, and les labour, if you are far from your mark, and not to go to it again, it oft-times will quit your pains, lest you are forced to spend perhaps an whole days-work about that you have done, or at least would have done already, to prove your angles after this manner.

C H A P. XVIII.

*To take terrestrial distances by the plain-Table, or Pandoron,
as by the Table.*

VV E have spoken of taking them by the chain only, in *chap. 13.* between that and this there is very little difference. We will here suppose the same suppositions as there: *viz.* two houses beyond a river, between which I desire the distance, also between each of them, and each of my stations: the chiefest difference is this, that by this your best way is to have your station-line as near the river as you can, which let be as before A B 40 pole long. First set your Instrument at A and turn the sights to D C, and B, and draw their lines; measure thence to B 40 poles, there make a prick, but lay down your 40 pole with a very small scale, if the distances be long, so that the 40 pole be little above an inch long. Then set up your Instrument at B, laying your index on your station-line of your plot turn it till through the sights you espie A, then fasten your Table and one end of your ruler turning upon the center B, turn the sights first to C, then to D, then draw lines whose intersections with the former will give you all your distances desired.

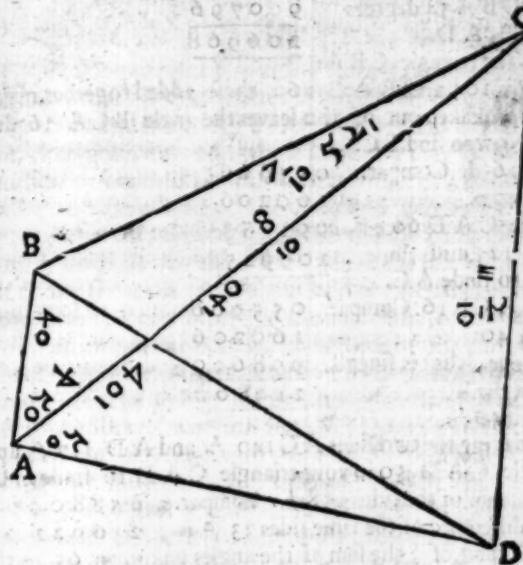
C H A P. XIX.

*To do the like by the Pandoron as it is a Quadrant, or by any
graduated Instrument.*

Let the same example be propounded as afore, and let your station-line be A B 40 pole as near the river-side as you can. I set up the Quadrant first at A, where I find B A D 110 degrees, and C A D is 50 degrees: likewise set up at B, then C B A is 104, whereof C B D 50; this station-line 40 and these angles thus plotted extend your lines till they meet, and their intersections will give you the desired distances as afore: yet if you will bestow the time and pains to cast it

up

Chap. 19. *The Faithfull Surveyour.* 59
up by the doctrine of Triangles you may come somewhat nearer.



First for the triangle BAD, seeing that BAD is 110 degrees, and the angle ABD 54 : which make being added 164 , which take out of 180 , rests the angle ADB 16 degrees.

Now in the same triangle having all the angle and the line AB : to finde the side AD .

As the fine ADB 16 . Comparithmes $05\ 59\ 66$
is to $AB\ 40$. $14\ 02\ 06$

So fine 110 degrees, that is fine 70 , $997 : 99$
to $136 \frac{1}{2}$ BD . $213 : 61$

Also to finde AD ,

H 2

As

As sine A D B 16. Compar. 0 5 5 9 6 6
 is to A B 40 pole: 1 6 0 2 0 6
 so sine D B A 54 degrees 9 9 0 7 9 6
 to 117 $\frac{1}{2}$ A D. 2 0 6 9 6 8

Then in the triangle C B A,
 C B A is 104 and B A C is 60, these added together make
 164, which taken out of 180 leaves the angle B C A 16 de-
 grees. Now to find B C.

As sine 16 d. Compar. 0 5 5 9 6 6
 to A B 40 p. 1 6 0 2 0 6
 so is sine C A D 60 9 9 3 7 5 3
 to B C 125 and $\frac{1}{2}$ 2 0 9 9 2 5

Also to finde A C.

As sine A C B 16. Compar. 0 5 5 9 6 6
 to A B 40: 1 6 0 2 0 6
 so sine 104, that is sine 78 9 9 8 6 9 0
 C B A 2 1 4 8 6 2
 to A C 140 $\frac{1}{2}$.

Lastly having the two sides A C 140 $\frac{1}{2}$ and A D 117 $\frac{1}{2}$ and
 the angle C A D 50 in your triangle C A D to finde C D.
 As the summ of the sides 258 $\frac{1}{2}$. Compar. 6 5 8 8 0 4
 to the difference of the same sides 23 $\frac{1}{2}$ 2 3 6 9 2 2
 so is the tang. of $\frac{1}{2}$ the sum of the angles unknown 65 to the
 tang. of $\frac{1}{2}$ their difference 11 degrees, 0 3 3 1 3 3
 which add to 65 d. $\frac{1}{2}$ facit 76 the greater 9 2 8 8 5 9
 angle D. But subtracted from it makes the
 angle 54 degrees: and then

as sine 54. Compar. 0 0 9 2 0 5
 to 117 $\frac{1}{2}$: 2 0 6 9 6 7
 so sine 50 degrees. 9 8 8 4 2 5
 to C D 111 $\frac{1}{2}$. 2 0 4 5 9 7

CHAP. XX.

*Of altitudes and distances celestial by the Pandorion
or Quadrant.*

For taking of altitudes and distances celestial, or altitudes terrestrial, it is a matter of necessity, that besides your Quadrant and three-legg'd foot, you get also a neck or piece of close-grain'd wood, whose Diameter may be about three inches, or somewhat more. Let the nether end be turned with a socket, that instead of the socket of your Table you may put on that, so that it may turn on the top of the staff as the socket doth, having also a screw-pin in the fide of it, to hold it at any situation. Also about two or three inches below the top turn it like a bowl, in the midst whereof bore an hole with an inch-wimble, to which fit a pin of the same wood, so hard both driven in and glewed in that it stirrs not; but let one end thereof be so big and so long as to fit the bras socket, that the socket may turn very stiff about it; and let the little end of the pin reach past the hole of the bowl, almost the depth of the socket, and then you may fit that end of the pin either to that or any other Instrument, by glewing upon it a piece of its own wood, turn'd like a little salve-box; then upon this pin put the socket of your Instrument, and work as followeth.

To take the altitude of the Sun.

Take the string of your plummet in your hand, and apply it to the edge of your Instrument, and hang it plumb: then screw it fast, then move the ruler with sights up and down, till the Sun shining through the sight next the limb, the shadow of the thread run streight along the rule, then look how many degrees are between the edge of the rule, and the bottom of the limb, so many degrees is the height of the Sun: and this you may do by setting it on a stool.

To take the height of a star.

To do this, having hanged your Instrument on the pin of

the neck, and plumbed one edge by the light of a candle, look by the edges of both sights, moving the ruler till you see the star desired in a streight line with them both, then screw the ruler, and take down the Table, accounting the degrees from the bottom to the edge of the rule for the height of the star.

To take the distance of two stars howsoeuer situare.

If both be near the Horizon and near of one altitude, and within 90 degrees of each other, you need not use the neck at all, but onely lay your ruler on the beginning of the degrees, then screw it, and turn the Table till by both sights you see one of the stars; then fasten the Table, and move the sights to the other star, and the degrees on the limb of the fiduciall edge of the rule gives their distance.

If they be both in one and the same half of a vertical circle, take both their heights as afore, subtract the lesser altitude from the greater, you have your desire. If they are in severall halves of the vertical circle, take the complements of both their heights, and add them together, & *actum est.*

But if they lie aslope, and yet are within 90 degrees one of another, then besides the foot and Quadrant, or Pandoron, get you two round sticks as big as your thumb, about six foot long apiece, sharpen their little ends, and nayl their great ends together within five or six inches of the top, with one nayl only, that they may open and shut like a pair of tongs: also you shall take a joynd-stool and cushion, and having put the neck upon the foot, and the Pandoron on the pin of the neck, close the three feet together with your right-hand, and lay them on the cushion, and with your left hand under-set the neck with the tongs, opening and shutting them as need is, or setting them nearer or further from you as need is; all with the same hand, and turning it aslope with the right hand. Then having first placed the sights at the beginning of the degrees, turn it till by the edges of both sights you see one of the stars you desire; then keep the Table fast there, and move the sights till by them you see the other star, & *voti compos eris.*

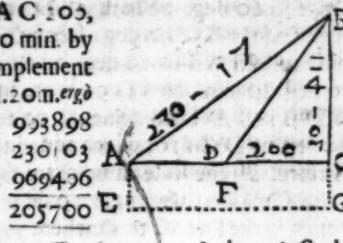
CHAP. XXI.

Of taking of altitudes terrestrial by the Quadrant.

There are divers ways whereby these altitudes may be discovered, whether they be perpendicular, as properly they signifie, or Hypotenuses, or bases: for all of them are comprehended under the notion of Altitude; because the bases may be as well found by the help of the perpendiculars, as perpendiculars by the help of bases, and any of these may be found severall ways by the Pandoron, either as it is a Quadrant, or as it is a Geometrical Quadrat: of either of which we will lay down some Problemes, and first as it is a Quadrant.

Probl. I. A distance being given and the angle of the base, to finde an altitude.

Measure the distance AC 200, and the angle A 29 deg. 40 min. by your Pandoron, the Complement wherof is the angle B 60 d. 20 m. ergo as fine ABC 60 d. 20 m. 993898 is to the line AD 200. 230103 so fine BAC 29 d. 40 m. 969496 to CB 114 (03. 205700)



II. Likewise the height CB given, to finde AC the distance.

As BAC 29 deg. 40 min.	969496
is to CB 114 (03.	230103
so B 60 deg. 20 min.	993898
to AC 200.	230103

To finde either of them by the scale and compasses, having the angle A, and distance AC.

First draw the line AC, set from A toward C 200 of some scale of equal parts. upon C erect a perpendicular, and upon A make an angle of 29 deg. 40 min. which line will meet CB,

CB, and you shall finde CB 114 fere. So measuring the height CB, and the angle B, and plotting it, you shall have AC 200.

III. The height BC and angle A being given, to finde the Hypotenuse AB.

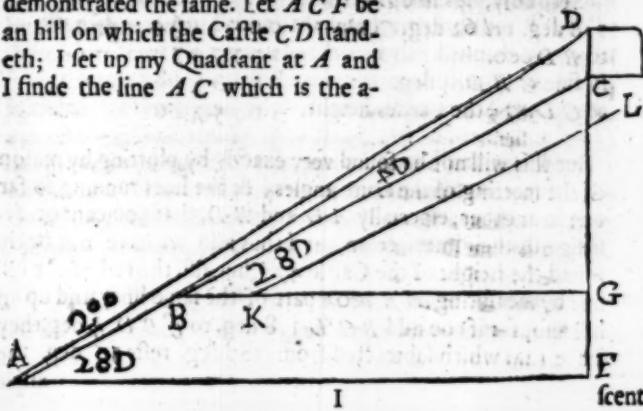
As A 29 deg. 40 min. to BC the height 114 (03: so ACB 90 deg. to AB 230 (17. To finde it by the scale. Draw the line AC let it be 200 of equall parts, upon C erect the perpendicular BC, and on A make an angle of 29 deg. 40 min. so the Hypotenuse AB wilbe 230 (17.

The part of the distance DA in the same diagram being known to finde DC or AC. Let AD or EF be 90 foot and I desire FG or DC, but I cannot measure it for impediments, therefore first take the angle of altitude B at both stations A and D, at A 1 finde A 29 deg. 40 min. so that the angle CAB is 60 deg. 20 min. at D 1 find the same angle D 46 deg. and DBC 44 deg. subtract 44 deg. from 60 deg. 20 min. resteth ABD 16 deg. 20 min. then say, As sine ABD 16 deg. 20 min. to AD 90 foot: so is BAD 29 deg. 40 min. to DB 158 $\frac{1}{4}$. Then again, As 90 to BD 158 $\frac{1}{4}$: so is DBC 44 deg. to DC 110, which added to 90 AD makes AC 200, as afore. By the scale thus, draw the lines AC and AB *ad infinitum*, making the angle 29 deg. 40 min. then set 90 feet from A in the line AC to D where you found the angle DBC to be 46 deg. because the angle CDB is 44, for they are the complements one of the other, therefore plot the angle BDC and it will be 46 deg. and the BD 158 $\frac{1}{4}$: then from B let fall a perpendicular upon AC, and it cuts it at C making DC 110 and AC 200 as before. To let this perpendicular fall divide either AB or DB into two equal parts, and with the compass at that widene's set one foot in the intersection and the other in the line DC at C and there falls the perpendicular BC and the end of the line AC.

Likewise any part of the altitude being known, the rest of it may be found by turning the height into the distance, and the distance into the height.

Any

Any part of the distance being known to finde the Hypotenuse. In the former diagram, subtract the angle BDC . 46 deg. out of 180 deg. or (which is all one) add DBC 44 deg. to $C90$, there rests the obtuse angle BDC 134, to which add the angle BAD 29 deg. 40 min. they make 163 deg. 40 min. whose complement to 180 is the angle ABD 16 deg. 20 min. Now say, As sine 16 deg. 20 min. is to 90 feet: so is 134 deg. which because it is obtuse above 90 deg. you must subtract it from 180, rest 46 deg. the acute angle BDC , and they give the Hypotenuse AB 230 (17). And for DB say, As sine ABD 16 deg. 20 min. to 90 feet: so is sine DAB 29 deg. 40 min. to DB 138 (4: for the plotting, if you mark how it is done in the last probleme, you cannot fail in this.) But as for taking all these Altitudes aforesaid, considering they are onely to be taken upon plain ground and that the chiefeſt uſe of this ſkill is to take ſuch altitudes as ſtand upon an hill: (For althoſh ſeverall writers talk of taking the heights of Castles, Towers, Forts, &c. yet they deſcribe them all as if they were upon plain ground, whereas it is a common thing to finde a Castle on hilly ground: ſo that I know not one Author that gives any rules how to finde the height of a Castle ſtanding on the top of an hill.) I have therefore here in this diagram demonstrated the ſame. Let ACF be an hill on which the Castle CD standeth; I ſet up my Quadrant at A and I finde the line AC which is the a-



scent of the hill to the bottom of the Castle 28 deg. of height, and the angle FAD 31 deg. to the top, the difference is 3 deg. which is the angle $CA D$: then I measure up in the line AC to B 200 foot; where if you suppose another horizontal $B'G$ parallel to AF , then must the angle $GB C$ be 28 deg. as before, by Euclid, prop. 28. Element. 1. there also I take the top-line by my Quadrant, viz. BD , and finde the altitude thereof GBD 32 deg. the difference is 4 deg. which is the angle $CB D$ and that taken out of 180 deg. leaves the angle DBA 176 deg. by prop. 13. Element. 1. to which add CAD 3 deg. facit 179 deg. that taken out of 180 deg. leaves ADB 1 deg. also add CBG 28 deg. to GBD 90 deg. they make 118 deg. which taken from 180 degrees rests 62, BCG , prop. 49. Element. 1. and the same 118 deg. is the angle DCB , for which in the analogie we take 62 the acute angle or complement to 180 deg. for the obtuse. Now to finde the sides say,

$$\begin{array}{l} \text{As fine } ADB 1 \text{ deg. Compar. } 1758144 \\ \text{to } AB 200. \quad \quad \quad 2301030 \\ \text{so fine } CAD. 3 \text{ deg.} \quad \quad \quad 8718800 \\ \text{to } BD 600. \quad \quad \quad \underline{2777974} \end{array}$$

$$\begin{array}{l} \text{Secondly, As fine } DCB \\ 118 \text{ deg. vel } 62 \text{ deg. Compar. } 0054164 \\ \text{to } BD 600. \quad \quad \quad 2777974 \\ \text{so fine } CBD. 4 \text{ deg.} \quad \quad \quad 88+358 \\ \text{to } CD 47 \frac{1}{2} \text{ the Castles height. } \quad \quad \quad \underline{1675726} \end{array}$$

But this will not be found very exactly by plotting, by reason of the meeting of the acute angles, & the lines running so far one in another, especially AD and BD , that you cannot distinguish their intersection, and thus also we have not onely found the height of the Castle $47 \frac{1}{2}$, but also the rest of the hill line by measuring AB 200 a part of the same line, and up an hill also, for if you add BCD 118 deg. to CBD 4 deg. they make 122: which subtracted from 180 deg. rests 58 deg. the angle

angle CDB: Then say,	
As C B D 4 deg. Compar.	1 1 5 6 4 1 6
to C D 47 $\frac{1}{2}$:	1 6 7 5 7 2 6
so C D B 58 deg.	9 9 2 8 4 2 0
to B C 776 (z.)	* 2 7 6 0 5 6 2

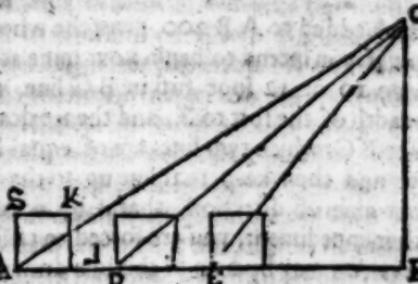
which added to A B 200, gives the whole line 976 f. 2. And now if you intend to begin your mine at B, your best way is to go 10 or 12 foot first in B G line, as you gheues half the breadth of the fort to K, and thence draw the line K L parallel to B C, which two lines are of equal length. *ELEM. I. prop. 26.* and then keep that line up to the top; for that must be your line of direction, that if by occasion of some rock, or other impediment, you are forced to raise, or sink, or go side-ways, you may by help of this line drawn on paper with a large scale, keeping account stil how far you are gone in the said line, and by help of the Quadrant at each station, be able to plot how much you are above or below your line of direction; and by help of your Needle to finde how far you are gone side-ways; but your best way is to draw one line for ascents and descents, and another for variations side-ways, besides your line of direction, and it will not be labour in vain also, beside both these lines to set down in a note-book the inches raised by themselves above the line of direction, and the fallings by themselves, that so you may subtract the summ of the lesser from the summ of the greater; just as in conveying of water, whereof we shall speak anon. Likewise set down the variations on the right-hand by themselves, and those on the left by themselves, and against what part of your directing line each of them is. Thus when you come within ten or twelve foot of the floor, there begin your Oven.

C H A P. XXII.

*Of taking altitudes terrestrial by the Quadrant,
or the Pandorum.*

The sides of the Quadrat S K, & K L (of which S K is called of *Pisicuſ*, the right shadow, & K L the contrary) are nothing else but the natural tangents of arches less then a Quadrant, which if each of these sides be divided by decimal division, they will agree with the Tables of natural tangents, either of *Blundevil*, or *Pisicuſ*, which holds in the contrary shadow, but because the contrary shadow is not continued straight on, but is turned again at 1000; therefore there it begins to be reckoned back again to 0, as Mr. *Wingates*, or Mr. *Gunthers* rule is. So that now if you turn A S down-ward, then K L will be the right shadow.

But to distinguish the right and contrary shadow, you must first consider whether your Quadrant goeth with a moveable rule and fight upon it, as *Pisicuſ* hath it; if so, then one edge is always plumb'd, then the right shadow is the horizontal above, and the left shadow is perpendicular; which if the ruler falls on it, the thing seen is lower then 1000 parts by his account. But by *Gunther's* Quadrat, which is with a plummet onely, and the centre upward, the plummet falls in the right shadow, when the thing is seen lower then 45. degr. of the Quadrant, or a 1000 of the Quadrat. But Mr. *Gunther* hath (in my judgement) expressed himself in doubtfull terms, in defining right and contrary shadow, where he saith that the right shadow of a Quadrat is that which is nearest



to the horizontal. May I not well ask what horizontal line he doth mean? or where is there an horizontal line in that kinde of Quadrat? Certainly there is none at all; what doth he then mean? he meaneth that that is the right shadow, that in taking any height lieth most level; and so it agreeth with *Pitiscus*: and although *Gunthers* rules are fully sufficient for his Quadrant, yet will they not serve to *Pitiscus* without some alteration. We will therefore beg leave of M^r. *Gunther* to borrow his rules, and to fit them to both.

1. *Any point being given to finde whether is be level with the edge.* by Gunthers, thus.

If looking through the sights, and seeing your desired mark, the plummet falls in the the down-right line next to you, then it is right and level with the eye. But by the other, fix the ruler on the lower side to the beginning of the degrees; then plumb the other edge next the centre; if then by looking through the sights, you espye the mark, then is it level with the bottome of the Table; or if you see by the top, then it is level with it.

2. *To finde an height at one observation by Gunthers.*

If looking through the sights and seeing the mark, the plummet falling on 100 of the Quadrat, or 45 degrees of the Quadrant, then the distance between the mark that is level with your eye it self, is equal to the height above the said mark. But if the plummet falling there, you see below it through the sights, then go further off; if above, then go nearer.

By the other, First, fasten your sights on 100 or 45 degr. of the Quadrant; then having plumb'd the side next you, go further off, or nearer, till you see the top desired through the sights of the ruler: then by looking by the over-edge of the Quadrat, see some mark by it also: so the distance from it to your eye shall give the height from the mark to the top desired. And what is here said of 100 of the Quadrat to give the true distance, understand the same, the plummet falling on 50 of right shadow, and the ruler on 50 of contrary, then to-

give a distance double to the height: if 25, the height is but a quarter of the distance; if 75, then three quarters: for as often as the plummet falleth on the parts of the right shadow, or the ruler in the other on the contrary shadow, as 100 to the parts on which the thread falleth, or rule cutteth; so is the distance to the height required: and contrarily, as the parts cut by the thread or ruler in the said shadows are to 100, so is the height to the distance. But when the thread shall fall on the parts of the contrary shadow, or the ruler on the right; if they fall on fiftie parts, the height is double to the distance; if on 25, it is four times as much as the distance: for as often as the thread falleth on the parts of the contrary shadow, or the ruler on the right, as the parts cut by the thread or ruler are to 100; so is the distance to the height; and on the contrary, as 100 are to the parts cut, so is the height to the distance: and what is here said of the height and distance, the same may be understood of the height and shadow.

*To finde the height or distance at two observations
by Mr. Gunthers way, by the Quadrat.*

As if the place which is to be measured might not otherwise be approached, and yet it were required to finde the height B C, and the distance: First, I make choise of a station at E (in the last diagram) where the thread may fall on 100 parts of the Quadrat, or 45 degrees of the Quadrant, or the ruler cut the like parts, the distance E B would be equal to the height B C: then if I go further-off in a direct line with the former distance, and make choise of a second station at D, where the thread may fall on 50 parts of right shadows, or the number 50 of contrary shadows, the distance B D, would be double to the height B C. Wherefore if I measure the difference between the two stations E and D, and this difference E D will be equal both to the distance E B, and to the height B C: or if you cannot make choise of such stations, I take such as I may, one at D, where the thread cuts 50 parts of right shadow, and the rule 50 of the contrary; the second at A, where they fall on 40 parts of their like shadows. Then suppose

pose the height BC to be 100 (for easines of calculation, though it be but 16) I finde, as 50 parts are to 100, the side of the Quadrat; so 100 the supposed height to 200, the distance BD . And as 40 parts at the second station unto 100, so 100 the supposed height to 250, the distance BA . Wherefore the difference between the two stations D and A should seem to be 50, and then if in measuring of it you finde it more or less, the proportions will hold, as from the supposed difference to the measured difference; so from height to heights, and from distance to distance: as if the difference between the two stations D and E being measured were found to be 30; As 50 the supposed difference unto 30, the true difference; so 100, the supposed height, to 60 the true height; and 200 the supposed distance to 120 the true distance, and 250 at the second station to 150 the distance BE .

C H A P. XXIII.

To take the situation of a plain for a dial, viz. the declination and reclinacion thereof by the Pandoron.

Apply one edge of your Pandoron to the plain, and the plummet to the edge next you; if that edge be upright, the plain is upright: if it recline, take off the ruler, and apply one of the edges next the centre that are not divided to the plain, so the degree cut by the thread gives the inclination. But if it recline, then turn the centre downward, and holding that thread in your hand, moving it to and fro with your thumb upon it a little above the limb, till the thread fall on the centre: so the degree cutting the line, shall be the reclinacion. Or you may put on the rule, taking out the sights, turn the centre downward, and one of the sides next it to the plain, turning the rule till the thread fall in the middle of it, then the fiducial edge thereof will give the degree of reclinacion.

But for the declination: Although you may go somewhat near by help of your needle and card, if there be no iron

iron near you; yet work as exactly as you can, I will be loth to trust it, but rather I will go further about, and finde it by the Azumeth; which to do, I must first by my Pandoron take the angle of the wall and Sun, thus: Apply one of the edges thereof next the centre to the plain, and turn the ruler till the Sun shews the shadow of the thread of the sight next the Sun, along the midst of the rule, then shall the fiducial edge of the ruler give the degree of declination. But you must mark whether it be taken in the fore-noon or after-noon, and likewise the moneth and day of the moneth: likewise you must at the same moment take the Suns altitude, thus; Either hang the Pandoron on the pit of the neck, or rather set one of the undivided edges on a stool, and plumb the other; then turn the edge of the Table to the Sun, moving the ruler up and down, till the shadow of the thread in the sight next the Sun shinc freight along the middle of the rule, so the fiducial edge gives the Suns altitude in the degree of the limb. Now knowing these things, you may finde the Azumeth either by calculation, or by your Pandoron, if you have Gunthers Quadrant drawn on it. First, by calculation having the moneth and day, you know the Suns place by this rule:

10	10	11	11	13	13	13	13	12	11	10	9
Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Octob.	Nov.	Dec.	Jan.	Feb.
VII	VIII	IX	X	XI	XII	I	II	III	IV	V	VI

12 tens, 2 elevens, 4 thirteens, 12, 11, 10, 9. These are the days of each moneth the Sun changeth his signe, beginning with March. If the day you seek the Suns place be after the change day in any moneth, subtract the change day out of the day you seek, and you have the degree of the signe of that moneth. Example. I desire the Suns place April the 25. 16. 6. I finde by this rule April 10, the Sun entred VIII, take 10 out of 25, rests 15: so I conclude, the Sun is in the 15 degree of VIII that day.

But if the day you seek be before the change day in any moneth, then first you must subtract that day from the change day, and then the remain always from 30. So April the fifth take

take five out of ten, there remaineth five, and that taken from 30, there resteth 25 degr. which being it is Leap-year, you may make it 26 of Y. of the moneth preceding.

Then you must seek the Suns declination either out of some Table for that purpose, or by this analogy: as the *Radius* to the sine of the Suns greatest declination 23 degr. 30 min. so is the distance from the nearest Equinoctial to the declination desired. Suppose April 5. the Sun in 26 degr. of Y., that is 26 degr. from the nearest Equinoctial; say, As the *Rad.* to the sine of the Suns greatest declination 23 degr. 30 min.

$$\begin{array}{rcl} 23 \text{ degr. } 30 \text{ min.} & 960070 \\ 26 & 064184 \\ \hline & 924254 \end{array}$$

so is the distance from the nearest Equinoctial to the declination desired 10 degr. 4 m. which because it is in a Northern signe, as Y & II & III & IV, therefore it is North declination, and is so much nearer then 90 degr. to the North pole, as the Suns declination is, viz. 79 degr. 56 min. Now add this distance, the complement of the altitude, and the complement of the latitude, all three together, and from the half summ subtract the distance from the pole, and note the difference. Let us suppose the Suns altitude taken about nine of the clock in the morning for the latitude of 52 degr. 15 min. took by the Quadrant as you are directed in Chap. 20, to be 32 degr. then proceed thus; The Suns North declin. 10 deg. 4 m. distance from the pole 79 d. 56 m. latitude 52 degr. 15 m. complement 37 45 the Suns altitude 32 degr. complement 58 00

$$\begin{array}{rcl} \text{Now say As the } \textit{Radius} 90, & \text{Summ } 175 & 41 \\ \text{to sine of the compl. of } & \text{half summ } 87 & 50 \\ \text{altit. } 32 \text{ d. i.e. S. } 58 \text{ d. } 992842, & \text{hence take } 79 & 56 \\ \text{so cosine } 52 \text{ d. } 15 \text{ m. or } & \text{difference } 7 & 54 \end{array}$$

$$\begin{array}{rcl} \text{S. } 37 \text{ d. } .5 \text{ m.} & 978690. \\ \text{to a } 4^{\text{th}} \text{ sine } 21 \text{ d. } .7 \text{ m.} & \underline{971532.} \end{array}$$

As this fourth sine 21 d. 17 m. Comp. At
to the S. of the half summ 87 d 50 m.
So is the S. of the difference 7 d. 54 m.
to a severall sine 15 d. 20 m. 028467
Add to it the Radius, the half 599969
thereof is the mean proportional, being the sine of 30 d. 58 m.
whose comp. is 59 d. 2 m. that doubled is 118 d. 4 m. the
Azumeth from the North.

Now suppose you had taken the wall and Sun 40 deg. that
must always be set backward in the course of the Sun from the
Sun or Azumeth: viz. from West to South, from South to
East, &c. So then our angle of wall and Sun being taken in
the morning, the Sun must needs be on the East-side of the Me-
ridian line, and being found 18 deg. 4 min. from the North,
that is 28 deg. 4 min. beyond the East, now if I set back 40,
that is take 28deg. 4 min. out of 40 there rests 11deg. 56 min.
from the East toward the North; and there
was the Sun when first it shone on the wall
thence draw your wall-line through the
centre, and always the distance between W
the East or West-line and the wall-line is
the declination desired 11 deg. 56 min. as
afore in Chap. 14. Now because the Sun
shines on it at noon; therefore it is a South diall, and because
the Sun shines on it longer in the fore-noon then in the after-
noon therefore it is a South declining East-ward 11 deg. 56m.
But if having the day of the moneth April 5, you take it in
the morning and the Suns altitude 32deg. and the angle of the
wall and Sun 40 deg. as afore, and you have Gunthers Qua-
drant drawn on your Quadrant for your own latitude, and
that you have your line of the Suns declination drawn on the
ruler as well as on the left-side of the Quadrant. And thus
you desire to know all things by it without any calculation;
First lay your ruler on the day of the moneth; see what degree
of declination is cut by that 12 of clock hour which is proper
to the time, whether it be summer or winter, carrie that de-
gree



gree to the Ecliptique and you have the Suns place. Also carrie it or take the same degree in the declinations on the left side: it gives the time of Sun-rising in the fore-noon hours and the setting in the after-noon. Lay the ruler on the deg. of the Suns altitude in the limb reckond from the left-hand, and your deg. of declination gives the hour of the day: carrie it to the right-side and reckon the altitude from thence, and the same deg. of declination gives the Azumeth either for summer or winter: but not from the North, but from the South. Then may you cast up your declination of the wall, having your Azumeth as you did before, or else finde it by help of a scale of chords drawn toward the top of the Quadrant on the right hand with a circle of the Suns Radius divided with two crois Diameters, and marked with East, South, West, North, and thereby with your compasses take your distances from your scale and set them out upon your circle. Further if you bring your deg. of declination upon your ruler to the Horizon, you have the Suns Amplitude in the Horizon also lay your rule in the place of the Sun in the Ecliptique it gives its right ascenti-on. If you bring your deg. of declination to the Horizon, the edge of the rule shewes in the limb the Ascensionall difference; which known, turn this Ascensionall difference into time, allowing an hour for each 15 deg. and 4 min. of an hour for each deg. it shewes how long the Sun riseth before six of the clock in summer, and after six in winter. If you bring the degree of the Suns declination in summer to any of the winter hours, and for morning hours of the one take the afternoon hours of the other, it gives in the limb the depression of the Sun below the Horizon. Bring the ruler to 18 deg. of the limb, and see where in summer the deg. of declination cuts the winter after-noon hours, and that hour is the break of the day: but in the fore-noon hours for day-light shutting in and the contrary; lay your ruler on the day of the moneth, make a mark upon the rule, where it cuts the sixth hour in *Faels* Quadrant, then lay your ruler on the Suns altitude in the limb and your mark, which give you the planetary hour. But it was

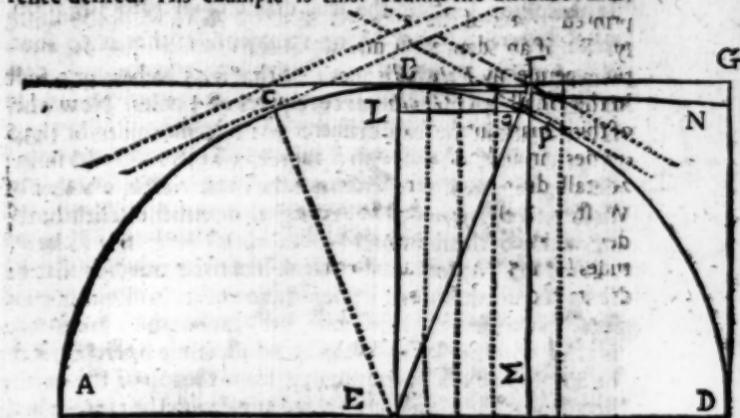
not my purpose to shew all that may be wrought by the Pandoros, so I may have work enough for a good while; but onely to shew the use of it in measuring of land, taking of altitudes, & conveying of water. They that desire more of the making & use of it in these things, let them see *Gunthers* book it self, or for the use of it let them see a little book thereof by it self sold by Mr. Moxon at the signe of the *Atlas* in *Cornhill*, together with printed papers of the said Quadrant for London-latitude onely. But if any desire the making of it for other latitudes, let them peruse my *Fate redivivus* or *Sun-shine of shadows*, wherein they shall finde *Gunthers* first chapter touching the making of this Quadrant explained, with Tables to make it for all latitudes throughout all *England*, and also Tables for all Horizontal dials, and for all erect South and North, East and West, and all decliners from one deg. to 90° for each whole deg. as also for all Polars, and all thele for nine severall latitudes from 50° to 56°, as also divers others curious dials Quadrants and Nocturnals.

C H A P. XXIV.

Of conveying water.

I find great difference among our best Authours concerning the odds or difference between the true and water-level. Mr. Hopson in his 24th chapter of his *Topographical-glass* saith, that after the ordinary manner to bring it in pipes, the ground must be lower by $4\frac{1}{2}$ inches for each mile, then at the spring-head: so that I suppose his meaning is, if it be 10 miles, it must be each mile alike, viz. ten times $4\frac{1}{2}$ that is 45 inches, or three feet nine inches; but neither demonstrates it nor gives any reason for it. Again Mr. Diggs in his *Pantometria* (lib. 1. chap. 3.) saith that in ten miles distance, the water-level is below the true nine paces, four foot eleven inches: which if every mile give a like we have five foot in a mile. And because there is such a vast difference, I will lay down both *Diggs* his rule to finde it, and his example, as he calculated it in his own words:

words: his rule is thus: First it behoveth you to get the distance of the fountain from the place whither you will convey the water, which distance you shall multiply by it self; adding the off come to the square of the earths semidiameter, and from the summ extract the square-root, and out of which root subtract the earths semi-diameter, the remain is the difference desired. His example is this: Admit the distance B.B.



10 miles. The semi-diameter of the earth E B ~~is~~ ^{for} Italian miles. But how the semi-diameter can be ~~is~~ ^{for} Italian miles, I cannot imagine: for if the semi-diameter be ~~is~~ ^{for}, the whole diameter must be 10022, which multiplied by 22 gives 220484: that divided by 7 gives 31498 the circumference, which divided by 360 deg. gives $87\frac{1}{2}$ Italian miles to a degree.

Now because an *Italian* mile is 1000 paces, and an *English* mile 1056, say, As 1056, 1000 : 87 $\frac{1}{2}$. 82. So that by this account there should be 82 *English* miles to a degree, which was never heard of; our common account is but 60. our modern Artists hold 66, the most that ever was reckoned of is less than 69, but this is 13 more.

But suppose the semi-diameter to be, as he saith, 5011 and
K 3 the

the distance 10 miles, each mile 1000 pases; each pase five foot, the square of 10000 pases, that is 10 miles, the distance is 100000000, and the semi-diameter in pases is 3011000, the square thereof is 25,1101,2100,0000, add both these squares together, they make

251102210000000

hence extract the square-root, it is 5011009 $\frac{9801919}{10002019}$

If hence you subtract the semi-diameter in pases 5011000, there rests 9 $\frac{9801919}{10002019}$ or 10 pases *ferè*, that is 50 foot, whereas *Hopton* hath 10 lines 4 $\frac{1}{2}$, that is 45 inches, or 3 foot 9 inches; so 40 miles distance requires 48 $\frac{1}{2}$ poles. Now whether we reckon the semi-diameter 3011 *Italian* miles, or 3436 *English* miles, 60 miles to a degree, or 3780 *English* miles, 66 to a degree, that decides not the controversie, whether of these either *Hopton* or *Diggs* is right, or either of them both, or neither of them both.

First for *Hopton* I cannot think him to be true; for that he sheweth no reason, nor demonstration of it: and although 4 $\frac{1}{2}$ inches may serve the first mile, yet I cannot think every mile is alike, for this water-level must of necessitie be supposed to be a right line drawn or running from the top of the earths hemisphærat, there making an acute angle with the tangent, and running between the said tangent and the earths Perimeter, such as the tangent-line BG in the last diagram. Now there may be infinite such lines supposed between the said tangent and the earths circumference, and is there not as good reason for all, as for any, for one as for another; there must be a *terminus ad quem* given, as well as a *terminus à quo*.

Besides all this, all these lines will be in the aire above the earth; but the water must not run above the earth (that is Gods decree) but in the earths Perimeter.

Therefore this difference of levels must needs be a line falling from the tangent-line, that runneth from the top of the earth to any distance desired, which (according to *Digg's*) is the excels of an Hypotenusal above the *Radius*, or earths semi-diameter, running from the centre of the earth to any distance of miles,

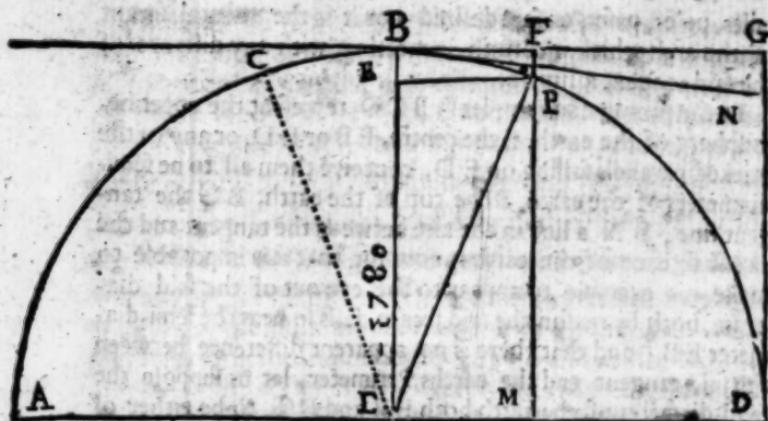
miles, poles, pases, or feet desired ; or it is the natural secant of the arch which it cutteth in meeting with any distance of the said tangent assigned.

In the former diagram, let A B C D represent the upper hemisphere of the earth, E the centre, E B or E D, or any of the pricked parallels falling on E D, conceive them all to be semi-diameters of the earth, B the top of the earth, B G the tangent line, B N a line in the aire between the tangent and the circumference of the earth : now for that it is impossible to make his example to appear to the eye out of the said diagram, both by reason the said secant falls so near the semi-diameter E B ; and that there is no apparent difference between the said tangent and the earths Perimeter, let us suppose the semi-diameter of the earth both E B and B G, to be either of them 100 miles, and let the distance B F be .40 miles, then the secant or Hypotenuse is E F, which for that it is longer by FO, than E B, therefore FO, is the difference of the levels found, as is before declared.

And although *Digs* neither doth set down the reason of his finding it after this manner; yet it is easily perceived of every one that hath any understanding in triangles : for it is but the finding out of the Hypotenuse of a rectangle right-line triangle, having the two leggs given, and it may also be wrought by the Logarithmes; but with little less labour.

Some think also that the line F P is the difference of the levels : but since the difference in 100 miles is almost insensible between those two, we will onely demonstrate it to you, and then let every man use his own discretion.

Let



Let us suppose in this diagram A B F D the upper hemisphere of the earth, whose semi-diameter E B is 3780 English miles, 66 to a degree, to which is equal both B G, and F M, and E D : for E D is equal to E B, *Element. I. Defin. 15.* and B G and E D. *Element. I Prop. 36.* therefore it is equal to E B, *Axiom. I. Element. I.* and F M is equal to E B, *Elem. I. Def 15.* and B G, and E D *Elem. I. Prop. 36.* therefore equal to E B, *Axiom. I. Elem. I.* and M E is equal to F B, *Elem. I. Prop. 36.* And because in the other example we could not distinguish one thing from another, because of the nearness of things one to another; therefore we will take the distance B F, which suppose 1500 miles, which (to save labour) we will keep still in miles.

First therefore, to find E O, E F, and O F, first E O is \equiv to E B, *Elem. I. Def. 15.*

for E F square E B, 3780. it is 14288400.

also square B F, 1500, it makes 229000.

these added make

16538400.

whose square root E F is English miles $4066 \frac{1}{4}$.

Whence take E B, equal to E O. *Elem. I. Def. 15.* 3780.

resteth O F, English miles

286 $\frac{1}{4}$.

Then

Now Then to finde B E F, whose natural sine is every where

As 3780 Comp. Ar. 642250

is to Radius :

So is 1500 317609.

to tangent 21 d. 39 m. of B E F, 959859.

whose arch is B O, whose natural tangent B F is 39694 parts,

and that is equal to L P. *ELEM. I. Prop. 36.* which is sine of

23 d. 24 m. for as 3780 3,577492.

to Rad. So 1500 13,176091.

to S. 29 d. 24 m. 9,598599.

whose complement is 66 degr. 36 m. and the sine thereof M P
91775, and the versed sine thereof F P is equal to L B 8225
parts.

And to reduce them into miles, say, 100000. 9225 :: 3780.

311. F P. whence take off 286 f, the difference is 24 $\frac{1}{4}$ miles
difference in 1500.

But how can we do so? since Mr. Frost (then Manciple of Emmanuel Colledge in Cambridge, since Sword-bearer to the Lord Maior, and since that a Secretary to the Council of State, a man beyond all exception for integrity of life, an excellent Mathematician, one that brought the water from the Spittlehouse to Emmanuel, and thence to Christ's Colledge,) told me, that he came upon a time (by mere accident) in the Fens to a place where an old river had run down some four miles, and was brought four miles back again in a new cut; and when they met, the water in the old was but four inches above the water in the new. Now the question is this, Doth not this confirm, or rather out-vie Hoptons tenent of four inches and an half to a mile, seeing here is but four inches in eight miles, which is half an inch for a mile? Truly I think not, for wheresoever you conceive your self to be, there is the true top of the earth: if there you are withall neither above nor below the true circumference of the earth, such as I conceive the Fens for the most part to be; having formerly been made level, as being part of the sea, I see not but that the water may

run both ways as well as in the sea; if not all four wayr, as well as the four rivers in the garden of *Eden*. And by this means if the meeting place was not some bowing of the earth of four inches thick, why might not they have met of equal height.

Every one (I suppose) will confess with me, that I being at B, the water will run to C, and to o; and if you turn C uppermost, will it not run from C to B as well? are no places uppermost but B, because I am not there: certainly I am some wonderfull vertuous fellow: well, I will get thither, and then it will run thither. If any dislike this answer, let him give us a better.

C H A P. XXV.

Of Instruments for conveying of water, and their use.

If your distance be not above an 100 poles or thereabouts, you may hang your Pandoron or Quadrant on the pin of the neck, and then set up a staff, or rather let one hold it upright, with his face toward you at the head of the water, moving a sheet of paper up or down, as you, standing 8 or 10 pole off in the water-way, shall direct him by the signe of your hand, till you having there set up your Instrument, and plumb'd it truly level, you see either through the sights, or over side of the Quadrant, the nether edge of the paper, having first screwed the ruler fast, and placed the thin edge thereof precisely upon the upper Horizontal line of the Instrument: now take not your stations above 10 pole at the most from your standings, both in regard of the refractions of the air which will deceive your sight, as also for that though your Instruments be never so true, yet if you fail either in your plumbing it, or in laying your ruler but one tenth part of an inch false, (which is easily done) you will fail so many tenths as are Tables lengths between your Table & your staff; which if your Table be 18 inches *Radius*, and your station ten pole, will come to eleven inches in that distance, enough to marr your whole work.

Now

Now he having placed his paper, let him bring it Raff, and all to you without stirring it; and then you having a two-foot rule, and a stick in your hand about four foot and an halftong, measure first the height of your fighes above the ground, also from the bottom of his staffe to the nether edge of the paper: if both be alike, then those two places are level; if not, then see which is most, and how many inches there are odds: if his be more then yours, then your ground is risen above them by so many inches as the difference is; but if you see more then his, then you are lower, and then the water will run, or else not. For it will never run higher naturally upward, unless your former falls do countervail your rise.

Having thus found the difference, you must in a note-book make two Tables, one for the risings, and another for the falls at each station, with their titles of rising and falling over them, and the number of inches at each station, and the number of the stations on the left hand: and you may do well also to measure the distance with a chain, and set down on the right side the distance from the spring-head, and at each station to observe some mark. And having all done, you must cast up the Tables each by it self, the inches of the falls by themselves, and the ascents by themselves: then subtract the lesser total from the greater; if the descents be most, it will run, so that there be no station in the way that is higher then the spring-head: which if you suspect, cast up both your Tables onely so far, and you may easily know. Yet if it should, that will not cut you off altogether: for though you cannot help your self by digging deep; yet it is hard, if you cannot by going about.

Having thus measured and found the difference, you may for triall-sake exchange places, and let him stand where you stood, and do you stand at the fountain. If there you finde the descent to be the same as you did before, all is right: and that you will hardly do, unless your Instrument be both very large, and very exact.

But now you must know, that there is a difference between
you

your being between the spring-head and him, and his being between it and you : for now, if he be most, he is lowest; for always he that is most is lowest. Now if you will, you may either your self go on forward, and let your assistant stand; or rather your self stand there still, if you remove not to prove, as I said; and so you may take two distances at one station; especially, if you have two assistants, and all you three are in one direct line: so if you keep your work in a streight line, if two assistants stand in the water-way, if you stand in the middle in a streight line, if you see to one of them, you see to the other without stirring the Instrument any ways.

Again, so far as you go in a direct line, if you have once set two marks level, you may easily by them set up a third and fourth as far as it goeth in a streight line; and when it turns then use your Instrument as afore.

Also it so falls out that water is to be brought out of some pond, or level water: if you bore holes in two boards like trenchers, and sharpen sticks of equal height with white papers on them, if the boards lying in the water, two assistants hold the sticks that you may set up a third in a streight line with them, with a mark upon it agreeing level with the other marks; if they are too high remove them lower, but both alike, or your own higher, & contrarie: onely take just notice how high the two are above the water, and then go on with a fourth and fifth so long as you go in a streight line, and then use the Instrument as afore.

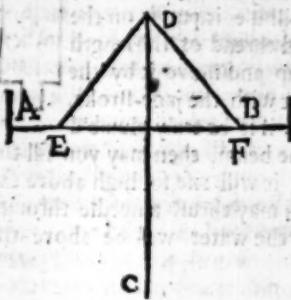
Also it may happen that you desire to bring water from some spring or head, but you have neither level, nor level water, nor streight water-way, but you suppose it will run, and the way is not long, and you would willingly try;

First then begin at the head, and make a little trench of three or four pole long towards the way that it will run streight, whether this be streight, or crooked it matters not; then let run so much water as may onely fill this trench: if you finde it dry, or shallower of water at the head, then at the other

other end, it shews the ground to be falling; then do the like with three or four poles more, still making the water to follow you, till you be gone three or four pole in your streight line; then having fill'd it that the water may stand level at both ends, stick up two sticks, one at one end, the other at the other, of equal length about four foot above the water, then go on 10 or 12 pole in the same line, where set up a mark, so that you standing behinde it, and looking to the middle mark, either all the tops or all the bottoms, according to which you measured your equal heights, may agree; then if that stick be longer beneath the mark then the other two, it shewes descent: if any rising places be in the midst, you may easily finde their rise by setting up a stick, and measuring it as before.

But for long distances, although I have fully shewn the use of it already in the Pandoron, yet because of the shortnes of the lines, there is as little reason for to use that in doubtfull cases, as for one to shoot at wild-geese a furlong off with a pistol, or to take on observation with a Quadrant of 3 inches Radius. I will therefore here give the making of a most excellent Instrument, soon made, and cheap enough. First, let

*For finding how
high you
may set
your cock
in a house,
see the last
page of
this Book.*



A B be a piece of deal, or some light and soft wood, about two inches square, or inch and half, and seven or eight foot long: in the upper-side thereof let there be a groove or chanel made with a round plane, like the chanel for a bed-cord, about an inch wide, and of like depth: likewise let ED and FD be two pieces of an inch broad a-piece, and a foot long, and half an inch thick a piece; to make brackets to be lapp'd one over the other at D, and likewise the beam with screw-pins made of pieces of old keys, to screw onely into the wood, without any forills at all, and likewise an other piece D G of six foot long, a quarter of an inch thick,

and an inch broad, with a jage-stroke down something toward one side of it, that you make the screw-holes beside it: this must be screwed together with the two brackets, within an inch of the end, all three with one pin. Also you must screw it to the beam at C, that the jage-stroke may be exactly perpendicular to the beam: this hole must be bored close to the bottom of the groove, and in the bottom of the beam you may glew on a piece of some eighteen inches long, in the middle, of two inches broad and an inch thick, to thicken it; because just in the middle you must make an hole so big and so deep, that it may fit to go on the top of the three-foot staff, or foot of the Pandoron, when both it and the neck are took off; yet you must take heed you bore it not quite to the groove, and let it go on as stiff as you can possibly. Also at either end glew on a piece of an inch thick, eight inches long, and of the breadth of the beam, or nayl them on to the beam, and cut the bases true and square: then get two thin sights made after the manner of this figure, eight inches long, and nayl them on to the ends at A B, so that the sight-hole of the one may look over the flat of the other, and when you will use it put it on the staff, and put on a plummet and thread of the length of the jage-stroke; then set it up, and move it by the feet till the plummet hangs right with the jage-stroke, then fill the groove with water: if it be truly plumb'd and that set perpendicular to the beam, then may you fill the groove so full of water, that it will rise so high above the wood at both ends, that you may thrust a needle through it close to the beam, and yet the water will be above the needle.

CHAP. XXVI.

Of flowing of grounds.

Mine intent is not here to describe the manner of making engines, sluices, *Cochleas*, mills, &c. to mount the wa-

ter

ter withall, as being too great a charge for a small piece of ground of nine or ten acres; for it often falls out, that if a piece of ground be ten acres, yet all of it will not be overflowed; so that, if you below any great cost, we may say *materiam superabit opus*; yet this I have seen in one of their dry years in a meadow near *Hartford*, that one man, having a piece of ground encompassed with the river, flowing it made five pound of an acre of his first crop, where his neighbour made scarce twenty shillings an acre of the ground adjoining; although naturally in other years before as good. Yet this is not comparable to land-flouds; for these, partaking of a slimy and muddy substance, being brought into meadows or pastures in the spring, either by drains, dams, turning of town-ditches, sewers, high-ways, streets, filths, do both moisten and fat them; wheras the river-water fats nothing so much; as *Virgil* hath it,

--- *huc summis lignuntur rupibus amnes,*

Declivemque trahunt limum. ---

And in another place,

Et cum exultus ager morientibus astut herbis,

Ecce, supercilio clivosi tramitis undam

Elicit, illa cadens raucum per levia murmur

Saxa cier, scatebrisque carentia temperat arva.

And doth not all the world know how the river *Nilus* fats with his slime the whole land of *Egypt*?

But now having by drains and dams brought your water to the highest part of the ground that you would flow, you shall cut a little trench, as level as you can ghuels by the eye, which in your ground let not be above nine inches broad, and seaven or eight inches deep; so going not above a pole at once, laying your turves on the lower side of the trench and close by it with the grass downward; that, if you think good, you may put them in again, or carrie them away: and now let in so much water, as will fill up that trench. If you have the water run over at the *left* end a little, it is the better; that so, stopping your trench with a turf, your water may run over in any place.

place. But if you are risen so, that the water will not follow you; then you should have a spade for the monce with a long crooked handle crooking up like a fire-shovel, that therewith you may deepen your trench; and take out the moulds; and then go a little lower the next time, still making the water to follow you as you go to the further side of the ground: then according as the ground falls you may make a cross-trench, one or more, in the middle, or at ends four or five pole downward; and at every four or five pole make trenches the same way you did at the first, till you have done: so that you shall need no water-level for this work, unless perhaps you need it to try whether it will come to the ground or no:

If you are to bring it over some ditch or brook, where the water is lower then your water-way; then must you either make a bridg over it, or else shooft four boards, and nayl them together, and make a trough, which may lie both under the ditch, and through the mounds of the ditch.

C H A P. XXVII.

Of drayning of grounde.

THe drayning of grounds is often found to be as advantageous and profitable; not onely in arable, but also in low meadows, and woods, and bogs upon hills, as the flowing of them: if not far more; by reason more grounds, for the most part, will be drained, then flowed, both in less time and with less charg.

The Instruments for this work may be a plow, spades, scopets, shovels, and bills, and forks.

In some Parishes they have a town-plow, that will hold eight or nine yoke of oxen, and a couple of horses afore for boys to ride on to guide them, and three or four horses with drivers on them, others to hold the plow (one one while, another another while) booted up to the middle, others following with bills, forks, spades, scopets, shovels; that, if any grass, or turf-ground fall in after the plow, some may cut

cut it to pieces with their bills, and others throw it out with their forks; but in plowed grounds with spades, scopets and shovels: thus yearly, about *All-Saints*, do they serve their pease-stubble, barley-stubble, and low meadows, especially commons. But this plow must have a piece of wood either screwed or cotered to the right-side of the beam somewhat toward the fore-end of it, to make another coulter-hole; that in sward-ground you may put in another coulter, that may cut both sides of the furrow: and let the ground-wrist be five or six inches broad, and the broad-wrist be longer, and stand out broader then the ground-wrist by an handful, to throw both earth, and turf a good way off. But, if you are in clay-ground, you may make a broader point then on stones or gravel; but howsoever let there be a whole pan and a finne-share.

Thus if you will make any new drain, ditch for quick-setting, brook, or river: first set up your mark at each nine or ten pole on both sides for the riders to guide on the horses, then plow once all over that breadth, and throw out the moulds; then set your horses single, and with any other lighter plow plow again and throw out, till you are deep enough: thus may you do more in an hour then in three days otherwise.

Likewise, I have known divers high-ways, where one fur-long hath abutted upon them, and another run long-wise by the side of it, where the way hath not been above a pole broad, that the plow continually carrying out moulds upon it hath so raysed that linsy-side, that it hath been so linsy that not a loaden cart hath gone on it in harvest or hay time since the memory of man, yet the most necessary harvest-way; this have I mended, and made level with mine own plow and mine own people in two hours, a quarter of a mile together; and the like have I done to raise a road-way in the middle by plowing and throwing up both sides.

Also I have known one M^r. *Field* of *Aspley-bury* in *Shidlington* parish in *Bedfordshire*, who there with his plow made a larg moat onely by plowing and throwing out the moulds, and making a ware for the horses to go in and out.

M

The

The same man also being at an especial friends house in *Hartfordshire*, his advice was requested abouit cleansing of a brook, which was filled with stones driven down the hill by land-stouds, neither could they dig it with spades, nor strike in a mattock; if they did, the water would fly in their faces, and the cold water overflowed the banks winter and summer, and spoiled all about: he gets a strong plow with a narrow-pointed share, and plows one hour in the fore-noon, and gets good store of labourers with forks and shovels, and throws out what the plow had raised, and then to plow another hour in the afternoon: and thus made quick speed without trouble or let.

Another time the same man stocke'd up a wood; and having openly stockt up the wood, he makes a plow, whose neck and handle were both one piece: with this plow he plows this ground, and never digged at all, onely he had two following him with mattocks, that if the plow was hanged in the middle of a great root, that the horse could not break it, then they cut it in sunder.

And lastly, one exploit more was by a plow done by Mr. *Taverne* of *Hexton* in *Hartfordshire* Esquire, Lord of the Town, who (because their high-way to *Lymn*-market was up an extream steep hill for two or three furlongs space, and often-times both in frost and rain so exceeding slippery an horse could scarce stand, being all a rock of burlock;) gets a plow, and the neighbours willingly bear him company: they plow about in a spiral line, and so plowed furrow after furrow, all one way, turning all the moulds down the hill; and so when they had plowed it broad enough once over, then they begin and plow two or three furrows of the moulds twice over, and the highest side deeper: thus doing, till they had made the highest side lowest: onely by plowing; so that they can now draw five quarters of wheat more easily up that hill with three horses, then up the other with five.

And thus have we the way to drain such grounds, wherein you may have the help of the plow. It follows now to speak
of

of those that must be done either chiefly by the spade, or one by the spade. Chiefly by the spade; called water-furrowing, that is, when you have new sown any grain whatsoever; then presently water-furrow it, either with plow, or spade, or both.

But if it fall out that in a flood the water goes not away so fast as it comes, though within two or three days after it will be clean gone; yet you are never the near; it hath done alreadie what hurt it can do, your grain is drown'd, and the fault is in the main drains, yet not in their depth; because they will be dry within two or three days after, but in their breadth.

Now, if this had been a new drain, you might have made it with the plow, as was said before: or if you will deepen this old one with the plow, it may be you may; but to make it broader you cannot, if it be either very deep, or very narrow in the bottom; therefore you must widen with the spade onely.

And for that where cattel go over such drains, they commonly tread in the earth, and stop up the water, therefore to prevent it, get good oaken timber, hew two sides of each piece, which let it be eleven or twelve inches Diameter, slit these in the middle, let them be two or threé foot longer then the breadth of the ditch, lay them edge to edge, the lawn side upward, nayl ledges on the out-sides; and lay gravel or earth on the top, and stop up with bushes, or ditch up, or both; the old going over.

For bogs and quagmires.

These for the most part come of spewing springs that are in a vein most commonly of gravel, near the superficies of the ground, and drawn still more upward by the heat of the Sun, or else in such places as formerly have been all water, as the Fens sometime have been, and so growing of weeds at first, they rotting have turned to earth, and the crop thereof every year turning to earth, in proces of time swells and grows up to a great height: as is manifest by divers rivers formerly navigable, now quite grown up. I have seen in *Maldon-moor* the

oots of two willow-trees in the bottom of a drain, about a yard deep in moorish-ground, within three pole of the firm ground, where one might see the stroke of the axe that felled them to this day: this ground about was excellent good turf, and on a sudden perfect sound, and so all along for twenty miles long, and in some places 30, 40, 50, 60 pole wide, it is good turf-ground: which makes me judge all was a navigable river in times past, as also the Towns names bordering upon it, as *Temsford-Islands, Sleaford, Elbet-haven, and Fleetwick*. Secondly, one *William Quayt of Maldon*, who yet is or lately was living, plowed up an anchor in a field called *Wickham-field*, adjoyning to the river. Thirdly, there is evident mention of a very strong Castle, at a place called *Bedlom*, situate upon a firm rock of hard red stone hard by this moor-side, and now it groweth daily more solid by draining, and I persuade my self will ere long come to be firm pasture: yet I do fully perwade my self it will scarce be so profitable then to the owner, as now it is. I remember before cutting of turves was known, a man might have bought in *Westoning-moore* in *Bedsfshire* an acre of meadow the free state for ten shillings: nay it was so bad, that scarce any man knew his own, they so little regarded it; yet since they have made fourty pounds of an acre, and yet have their ground still, which in 30 or 40 years they make as much more. Now if your bogs be so tender, that one cannot go on them, then at the upper part where it first riseth make a large & deep ditch, so deep that it may be lower and deeper then the springs by a foot or two. This convey so, that no water may stand in the diteh, so that the water of the springs may so be cut off; making a ditch, though not so big, round about: and when it hath drained thus a while that you can go upon it, then dig drains with turf-spades aske up the hill, as deep as you can, and some twenty foot asunder. And thus (in short space) you may have either good turf-ground, or hop-ground, or Orchard, or pasture at your pleasure.

C H A P . XXVIII.

To cleanse a ditch, whether it be full of slagg, or mud,
and not empty out the water.

If it be full of weeds, get a drag or dung-rake with three teeth, and drag out the weeds: likewise for the mud, get a mud-pat, which is made of the back of an armour, make a socket, and slit the little end forked, and flat it, and spread it four or six inches, and rivet it on the plate, then rivet another round piece, both close by the socket, and also into the bottom of the plate to strengthen the forks, setting it coming toward you as your drag-rake doth. Then, if there be much mud, draw out some of it first all along the ditch, and when that is hard, so that you can go upon it, then draw out more. Thus may you go to it when you will, and leave when you will, without dressing you, or damming the water. And thus one man will draw out as much in an hour, as three men will throw out with scopes.

C H A P . XXIX.

Of cleansing a Pond six or seven pole broad being grown over
with a coat of weeds, that it will near bear one.
without abasing the water.

You shall for this purpose get a boat and a haling-line; a good store of drags, cutting-knives of both sorts, such as they cut mows or hay-stacks with, both like sickles, and stabs; also wheel-barrows, and half-inch boards of six or seven foot long apiece. If this coat of weeds be very soft, you were best to nayl two boards together, with ledges like a door: but if it be any thing hard, let them go single. Then begin with your crones or drags, and cleante the out-sides with them first as far as you can reach, and let the barrows carry it away out of your way: then take your boat and spre, and for want of a boat take a Brewers cooler, and let two folk go into it, and row your selves to the crust, and laying

your boards on it, and you standing on them, cut with your sithe pieces as long and broad as the board, then take up that board as you stand on the other, and remove it beyond it, then take you the crones that stand on the bank; and having fastened your haling-line both to the crane and to the stale of it by knitting a knot at the handle-end, let them on the bank draw out those pieces: which that they may do the more easily, they may level a place about an handful above the water, and pull them thither, and then cut them smaller with their stabs, and then draw them up.

Now then having thus gone round, and cleared it from the sides round about, pitch all your crones into one side of the core or crust, and trie if you can draw it to the bank-side (for these kind of cores never grow to the bottom, especially if the water be deep) which if you so draw it, then may you standing on the bank finish all with your crones. But if you cannot move it, then with your sithe-knife, and help of your dores and boards, you may slit it all along, either in the midst, or as much as you think you can move at once. But now because you must move your boards and dores end-long, (which is harder to do then side-ways) your best way is to have a hook at the end of your haling-line, and make a mortes at one end or both of each board, and thus put the hook in the mortes of the hinder door, and raising it a little at the end with a couple of chisils, or such like, draw it till it is entered upon the heather dore; then having a board lie by the side of it, stay your self on it, till the hinder be drawn along upon the other, and lie foremost, and thus may you divide and draw piece after piece till you have finished.

C H A P. XXX.

Of cleansing of water.

SOMETIME you are to bring water to an house, but you have none but such as comes from noysome places: now to purifie such water, if you make a trench of a foot and an half deep and

and three or four pole long (the longer the better) and fill it a foot deep with hurlock or clunch cut in pieces, as it were for the lime-kiln, then fill it an handfull higher, with pebles, then fill it up with gravel or earth; it will so purifie it, that it will be fit for brewing, or the pot, or laundrefling, or any thing else: if you cannot get hurlock, content your self with pebles. Also it greatly meudeth water in a pumpe or well, first to cleanie out the mud, and then to put in clunch into it. It will likewise purifie the water very much, if you would lay clunch or hurlock as high as the water rieth in your well, in the same form that they use to lay their brieks: so will the water cleanse it self by draining through the body of the clunch.

C H A P. XXXL

Of quenching an house on fire.

THe Instruments for this purpose (not to speak of the water-squirt, which will throw a whole hogs-head of water to the top of an house at once; for that such are scarce to be had; save in some great Towns or Cities) are pikes, spits, mawkins, pike-staves, forks, wet-blankets, ladders, buckets, scopers, pails, &c. and the materials, water, coal-dust, turf-ashes, wood-ashes, sand, horse-dung, dust, dirt, and in extremity even drest-grain it se'f. I know you will think it strange, that I should mention pikes, and spits, dust, sand, and ashes; but I speak on often experience, that four men, that know how to use these things, will sooner quench a fire, than 100. that go to work with ladders and buckets to strip houses, and hooks to pull them down. It's a misery to speak it, when the rude multitude are once come together every man will have his own way. If it be a dwelling-house, some will busy themselves to carry out bras, pewter; but their chief aim is at the mony-chest; whilst others wait to take it of them, and carrie it away: others perhaps, of more honesty but les wit, will be ripping the house, and so let the fire have the more air to burn the more violently; that, whereas they think thereby to save other houses,

houses that are near to it, they use (for the most part) the onely way to fire them: for the greater the flame is, the more is the danger, and the farther the sparks of fire will slie. And now, if you will vouchsafe the reading, which is no great labour for you, I shall endeavour (God willing) to give you such directions, whereby you may with least loss, least help, and most speedily quench any fire, wheresoever it begins, or howsoever it comes.

The first rule is this. If it be in house or chimney, do not by any means open any vent to let it out, especially upwards; but rather stop all the holes you finde. If the soot of a brick or stope-chimney be on fire, discharge a pistoll twice or thrice upon it; so soot and fire and all falls together. If it be a wooden-chimney, and that all the timber, both ground-sells, studs, mantle tree, beams, and all are on fire at once; then first with your pike-staff, fork, or spit, rub down all the coal, then throw on water, and then ashes, and all is done. And thus did I my self, all alone, quench a fire at *Westoning in Bedfordshire*, where coming that way accidentally, and meeting a woman coming out of a yard wringing her hands and crying. I asked her the reason, but she gave me no answer, (whether it were for that I was a stranger to her, or whether for grief she could not speak, I know not:) but away she runs as fast as she could. *I fearing some such matter ran into the yard, but finding the door lockt, and hearing withall a fluttering of fire, I took up an hogs-trough which lay there, and ran against the door, and broke it open, and went in, where I found a buck of clothes standing on a tre sole, and a great many turves under it almost burnt out; yet the buck had no hurt, but they had fired the end-ground-sells, studs, and all the timber of the chimney. I having been at the Fullers earth-pits, not far from *Oburn*, to survey them, had the foot of my plain-Table in my hand, where-with I rubbed down all the coals, and then took the buck-cloth by all the four corners, and threw up the ashes into the chimney, and finding a pail, I ran and fetcht turf-ashes and water together, and quenched all quite in a quarter of an hour.

hour. All this while not one body came; so I was going thence, and as I was going out at the gate, there came near half a score, which she brought out of the field from haying; with these I went back again, fearing lest they should do haste, so presently some of them get ladders, and to pulling off the thatch, but I prevailed with them with much ado to let it alone, and willed them by all means to keep it into the chimney: if they found any holes that it could come out at, to stop them up with dirt or cow-dung, and throw dirt or cow-dung on the thatch if they would, and if they saw any more fire in the chimney to cover it with a wet-blanker.

If it be within a dwelling-house, on any ground-sels, or studs, it is easily quenched, doing as afore.

If it be between parter and loft-boards, wheresoever it breaks forth, lay on wet woollen-cloths, hair-cloths, cow-dung, or horf-dung, with water, ashes, or sand.

If it be on the inside of an house either thatched or tiled, between the parter and the roof, cover the out-side with wet blankets, hair-cloths, &c. that neither the flame get out, nor air get in. And on the inside be sure there be no vent in the parter, but stop it with cow-dung, &c.

If it be on the out-side of a roof, cover it with wet woolen; or on the top of a mow: and throw no water, but ashes, sand, horf-dung, &c.

If it be on the inside of the roof of a thatcht house, cover the out-side with wet cloths as afore. If there be no parter, your onely Instrument is a scovel, or mawkin, or mop often wetted, and with them sweep down the fire. And thus I and a boy with a scopet, throwing in mault instead of ashes, did at *Tame* querch a thatcht-house adjoyning to another in the market-place, which was on fire in eight places at once: on the inside, hard by the eavs, yet being new thatch and hard, it glaunced up to the roof, and broke not out, till it came at the ridge, where were on the out-side as many people as could stand on ladders, ready with water, that no sooner could a flake of fire peek out of the ridge, but streight they saluted it

with a bucket of water : but for all that, so soon as the fire had broke out at the eavs, (which had been, had not we two asswaged it,) they must all have sought a new way down, or else have gone through the fire.

If it begin likewise upon hemp, or flax, cover it with coverlets, blankets, hair-cloths, &c. and throw on ashes. If it be on the side of a mow, hang wet hair-cloths, or woollen-cloths before it, and cover it at the top, that no flame get out, holding the fore-side-cloths as close to it, as possibly you can. Thus have we shewed the ways, how to quench fire in any house, where or howsoever it shall begin, without pulling down. Now to prevent fire coming from another house, cover it with hair-cloths, coverlets, &c. and throw on them water'd ashes, dirt, dung, &c. Also if an house be pulled down, by no means let it lie there; but, be it what it will, timber, or grain, hay, or straw; quench it throughly, and get carts and away with it into the field, and there spread it. I saw one at *Burton in Bedfordshire* at one *Francis Woodward's*, who had his barn burnt down, that it kindled again in the carts before they got a furlong from home. And I have heard my Father speak of it often, that there was a Parsonage-barn, with much corn in it, burnt down at *Leighton-Buzzard*, where he was born, and they did not carry it away, but watched it continually; but for eight nights together still about mid-night it broke out again, that they were forced to ring the bells, and to carry all away at last, when they had wearied them with watching.

If any shall doubt of the efficacie of these things, I desire him to consider of these five things.

First, He seeth dayly, that an extinguisher puts out a candle; yea a candle puts out it self by turning the flame downward: then a blanket on a chimney, or any where else, much more.

Secondly, If any doubt the blanket will burn; it may be so, if it have holes in it: but they are easily stopt with throwing on horse-dung, or dirt. And for both these let him try this conclusion: Let him take a woollen rag, and a burning coal either

either of wood, sea-coal, or turf, (which of all other is hardest to be extinguished, and therefore we use to take a piece of turf and wet it, and rake it up in the ashes to keep fire, yet) let him wrap this coal in his cloth, or lay it on the hearth, and cover it close that no air can get in, and your coal quickly dieth.

Thirdly, Ask any soldier, and he will tell you, that the best way to put out his match is to put it into the mouth of his piece with the coal down-ward.

Fourthly, You may easily see the effect of dust, sand, horfdung, or such like, if ever you saw an hearth of char-coal burnt, and quenched.

Fifthly, If a mow should be covered at the top, and not at the end, you will say it will burn underneath like an oven; Answer, put a whole fedge-sheat into an oven at once, let it be at full fire, stop up the oven, and presently the fire goeth out.

CHAP. XXXII.

Of keeping a fire light all night with a farthing-charge.

I have before, in the last chapter, shewed you how to put out fire: now in this I will shew you how to keep fire a long while light with a little charge. Suppose you dwell in a lone-country-house, where one is sick, and you have but one farthing-candle in the house, and borrow you cannot, and you would fain have it last burning a whole long-winters-night; then do thus. Cut your candle in two pieces, light one of them; and heat a great pin, and thrust it into the great end of the candle long-wise half the pins length, then fill a pail with water so deep that the length of the candle, pin and all, will not reach the bottom; then holding the candle by the light, let it down gently into the water with your fore-finger and thumb, till it comes to the flame, there staying it a while till the water be still, and then take away your hand; so still, as the candle burns the flame will raise it: and which an-

swers the whole business, that the fire will go no otherways,
Save upward to his own element.

CHAP. XXXIII.

Of laying down of ground for pasture.

OF all ground the best to lay for sward is the black-mould,
or strong clay. And although the black-mould be excel-
lent both for Wheat, Barley, and Beastes; yet in the low le-
vel ground it is infinitely more commodious for pasture in sum-
mer; that the three years crop of grass without any charge at
all is more worth then your two crops of grain with all your
two years seed, your dung, and carriage, and five or six
plowings, harrowings, rowlings, and weedings. But you
will say, ground is long in grassing, and I am but a Tenant,
and have but a short time in my lease; when I have made it fit
for another, my Land-lord will turn me out, or make me pay
more rent. This, I confess, is something, and in some cases
may serve for an answer; but yet upon this condition thy
Land-lord will renew thy lease for one and twenty years, (if
he be wise) and then you are well enough: for whereas you
say it is long in grassing, that is remedied with one years
charge of arable; for if thou first plow it, and lay it flat, and
with as few furrows as may be, about November, and then
dung it, then plow it again, about the beginning of March,
still laying it flat, and filling up the furrows; then sow it with
hay-dust, or chaff-dust, which every horf-keeper, if they are
spoken to about Michaelmas before, will (for a trifle) save
for you on purpose. If you harrow in this, you shall have a
crop of grass at Mid-summer, will be worth 30 or 40 shillings
an acre, and still be better and better. But by all means plow
in your dung, I have laid some in that maner, and some I
have dung'd above ground three times, yet this will not be
comparable to the other; yet but a furrow of a plow between,
and both laid down 40 years ago.

And by no means lay down any ground, that is worn out

of heart; for by thas means if ever thou get good grass of it in 40 years, I'le never be trusted, unlessthough dung it extraordinarilie; and yet it will not do. Rather this do; if it be inclosure, take nothing but the mowing crop for divers years together, and so doing that crop will be more worth then two whole years crops taken as ordinarily. I speak all this of mine own experience upon my own grounds.

But I have often heard of, and in part seen another sort of speedy grassing, which is this. They sow their ground with seed of claver, grals, a very small quantitie on an acre, and in some places they mow it twice in a year, yet nevster sow it but once. Whether they plow it or not, I cannot justly tell: I think not. Thus I have seen at *Maddingley* three miles from *Cambridge*, they have their common fallow fields till *Midsummer*; and then have an exceeding crop of claver, and then fallow. But whether they sow for each crop, or whether it be of the nature of Mustard-seed, that need never be sown but once, though the ground hath lien fward 40 years before, I know not.

But you will say, yours perhaps is common field, if you should lay it fward, you shoule lay it for other folks. And what of that? If you have more benefit that way, then you had before, never grudge at it, though others take a part. 2^{ly}, Thou shalt take part with others of it, as they do with thee. And in most places one acre of sward hath as good right of common as three, or in some places five acres of arable hath. 3^{ly}, There is no doubt but others seeing thy good and speedy succels will soon second thee, and then thou shalt have as good benefit of his, as he hath of thine.

Ob. But if every one should lay sward that would, how shall we do for bread? I answer, I do not say I would have every one that list should lay down for sward; but this I say, I would have all ground turn'd to the most advantage, first of the Common-wealth, then of the owner: I would not have such ground, as will bear two or three load of as good hay as ever beast eat, turn'd to arable, when the next acre to it being sown some years hath scarce yeelded the seed again. Where

an ordinarie acre of pasture is worth 50 shillings per annum, and the best arable not above 8 shillings; for as for an acre of sward, though it be worth but 20 shillings to the owner, yet to the Commonwealth it is worth 30 shillings the after-pasture, where it is reckoned at a third part of the rent, with us at Cambridge far more: and that is not lost, it doth not vanish into air; and though the Master get it not, the Commonwealth doth; and how would *Luton* and *Hitching* do for hay, were it not for *Hartington*, *Putney-hill*, *Gravenhurst*. Or how would Cambridge do, were it not for the Fens? Yea, I have known that hay hath been carted out of *Bedfordsire* to *London*, thirty five miles. And I am sure, that it is an easier matter to drive fat cattel an hundred miles, then to carry corn fourty by land. Neither would I have *Chiltern-ground* turned to pasture, because there an acre of arable is more worth then an acre of pasture. Yet certainly it plainly appears by this, that generally there is more want of pasture in *England* then of arable; for that we have daily fat cattel brought out of *Ireland* and *Scotland*, but never any go out; but where grain comes in once, it goes out ten times.

C H A P. XXXIV.

Of the chiose of a rich ground.

FOR a generall fat soil, and such as is good for all things, or at least most things, both grass and grain, (for indeed no ground is fit for all things, *Non omnis fert omnia tellus*) the black ground of a good deep staple, with a mixture of gravel or sand, is not unworthily commended of the Poet, *Lib.3. Georgic.*

*Pinguis item qua sit tellus hoc denique gallus
Discimus; haud unquam manus jactata fatigat, et
Sed picis in morem ad digitos lente scit habendo;
Humida maiores herbas alit, ipsaque justo
Leiori ab huminum ne sit mibi fersilia illa,
Neus pre validam primit ostenter Aristis,*

For this we commend *Ailesbury*.

And some extoll as highly earth that is of a reddish colour; as the ground about *Armagh* in *Ireland*, which (some report) hath had no manner of manuring since the memory of man. I know some such black ground in *Pullox-hill* afore-laid, but I know no such red. *Virgil* also saith, That if you dig a deep hole in the ground, and fill it up again, if you cannot tread in the earth again, then it is rich arable ground, 2. *Georgic*.

— *altèque jubebis*

*In solido putum denuo: omnènque repones
Rursum humum: & pedibus summas aquabis arenas.
Si detrunt, rarum pecorique, & vitibus almis
Apricus uber erit: sin in sua posse negabunt.
Ire loca, & scrobibus superabit terra repletis
Spissus ager: glebas enlantans, crassaque terga
Expecta, & validis terram profunde jacentis.*

Also a sweet smell after the first rain, or a drought, or after new plowing, is a token of a rich soil. Also where thistles, nettles, or other weeds grow rank. Also where trees grow long and upright. Also where fruit, especially pears, are more pleasant in taste than in other places: for if a young pear-tree bears pleasant pears in a good ground, and you remove it into a bad ground, you will think the fruit not to be of the same kinde; yet all grounds are not alike for all things.

— *Non omnis fert omnia tollus.*

And for the mostpart, those grounds that are most barren above, are richest within, as stone-pits, fullers-earth, lead, coal, tin, silver and gold-mines.

Some grounds are fitter for wood, then either for corn or grass. I have seen a ground in *Hartford-shire*, that hath been laid two years, where were grown naturally black and rank fallows all over the ground in tussocks, some six, some seven foot high, so that the crop of wood was more worth then the crop of grass.

C H A P. XXXV.

Of enriching lean ground.

Lean grounds are either enriched with rest, or with dunging. As for pasture, if you neither eat nor mow it two or three years; or ohely mow it once a year ; or if you will eat it, By no means eat it too low, and you will greatly thereby both better the ground, and get a speedier increase of the crop; for after it once covers the ground, it grows more in a week, then in six weeks before, by reason it keeps the ground both hot and moist, yet not so hot as to be scorched with the Sun: therefore be sure to spare such barren grounds by *Candle-mass* at the furthest. As for lean arable, though common-field ground, it is a common thing in divers places, where they have a great deal of lean land that lies far from any Town, to let some thereof lie lea six or seven years; and the longer it lies, the more heart it gets.

As for dunging, the benefit of horse-dung and cow-dung is every where known in part, yet not to all alike, some will not lay it on their land till it is rotten, but will carry it out of their yards, and lay it on dung-hills in the field, either at the lands end, or some place near to it, though the land be not then sown: whereby they make a double labour, and lose a double benefit of their dung, which they may easily finde by this, that a great part of the strength of it goes into the ground it lies upon, as appeareth in this, for if they lay it in small heaps on the land where it should be spread, if it lieth long unspread, let them spread it as clean as they can, yet those places will be ranker corn then the rest. A second benefit which they lose is the stiving upward, which in dry weather should be the onely nourishment to the corn. If you please to try two acres of like land lying together, and carry out twenty loads of horse-dung about *Mid-summer*, that is new-made, as such you may have at an Inn, and lay that on a heap in the field by it self till *February* or *March*, and then fetch twenty loads more of the like, lay these twenty on one of the acres, and the heap
on

on the other, but let your loads from the Inn be alike; and then tell me which acre is the best barley. But though you finde but little difference in the barley-crop, you shall finde a vast difference in the peaf-crop. And if you will sow them three years together, there will be no small odds, for the stiving of the dung will be over in two or three years. And this also will appear, if you take a load of straw, and lay it in some Orchard, where no cartel come upon planks, boards, or stones, and spread it so that the rain may get into it, and turn it three or four times in a year; and by three years end you will hardly have a quarter of a load of dung left; and that which is left will be turned to earth also: yet I deny not but that earth may be better then ordinary.

Also street-earth, especially in Market-towns, where goes ^{Street-}
store of sinks from stables, kitchens, dairy-houses, but especial earth.
ly cisterns for malting. I have known them that have got up all the pif they could get in a Market-town, and carried it to their land in a run, and there strewed with good success. But if they, that have such convenience for carriage, woud but make triall of the water of the sink of a Cheef-pfess, or of cistern-water, I doubt not but in short-time there would be little of it lost.

And we see now how much soot is set by, which within ^{Soot.}
these fifty years men would not suffer to be thrown upon the dung-hill, but into the midst of the street.

And although, by *Moses Law*, some great offenders were ^{Salt.}
to have their land sown with salt; and likewise in *Judges ix.*
45. Abimelech, when he took *Sieben*, destroyed it, and sowed it with salt; the reason was, that it should never bear grass nor grain. And indeed it is an easie matter, either with soot, salt, pigeon-dung, or pif, to over-dung and spoil all. I have known some carry out pigeon-dung in sacks in *May*, and lay a sack-full on a heap upon the corn; but they could not gather it up so clean, but they kill'd all the corn as far as the heap lay.

I have sown pigeon-dung in an extream hot and dry year ^{Pigeon-}
upon ^{dung.}

upon batley, on an hot and dry land, when it harvest the batley hath scarce pecked out of the hose, yet it hath been the best in the furlong. Again, I have in a wet year sown pigeon-dung on land, when my crop hath been more worth then the see-bimpie, or value of the ground.

Folding of land. Land that is folded a little before, or presently after the sowing, doth far better then otherwise. But herein many men wrong themselves in surfeiting their sheep in Summer-time, when their fold goes on single-lands as on roods or half-acres, in laying them so thick, that they overheat one another, thinking that if they have as many hurdles as they had before, that then they lie as thin as they did before; but this I have spoken of before in the first Chapter, where also I have shewed the disproportion, and therefore to it I refer you. Yet before I leave this, I must add further, that I see no reason why other countreys may not fold in Winter as well, or rather, then Oxfordshire, or Buckinghamshire: nay, far rather, either upon fward or arable, especially Hertfordshire, or Middlesex, if they will do as they do, that is, winde their hurdles on two sides with broom, and remove their hay-rack and cratches with their folds. *Hertfordshire* hath far drier laire, their sheep more hardy and sound, and never rotting, more hedges to shelter them, and dung infinitely dearer. And if they broom their hurdles to keep them warm, then why not to keep them warm by keeping them together? I never knew sheep take hurt by lying warm in Winter. If you will not fold your arable, yet fold your fward, if not your fward remote from the hedges, yet at least your hedge-rows. It is the office of a land-meter, to give the quantity or measururation; but the office of a Surveyor, to acquaint you with all means of melioration.

Rags and Horn-shavings. Now we are come to rags and horn-shavings. It is almost incredible the odds of an acre of the best barley in *Hitching*-parish fifty years ago, and twenty years ago, and all by buying rags and horn-shavings at *London*, carrying up malt, and bringing them down all the year long. As for their rags, they carry them to the land, and lay them on heaps like dung-heaps, but

not

not so big; then chop them in pieces on a stick with a hand-bill, and then plow them in, and these and horn-shavings endure along while, and have so imended their soil thereby, that whereas about fifty years ago, an acre of their barley was not above three pounds ten, or four pounds the bushel; now about twenty years ago, I was requested to measure two acres of barley in a field called *Kings-field* in *Hitching-parish*; that the very crop of them was sold for nine pounds an acre by the Statute-pole.

Malt-dust also is little inferior to Pigeon-dung. Also lime, ^{Malt-}
five or six quarters to an acre. Ashes of all sorts. Chalk for ^{dust,}
all red grounds, both arable and sward. Scowring of old
ditches, good for all white grounds and clay. Also marl of ^{Lime,}
ponds, where flocks of yards run into them; but in a spring or ^{Ashes,}
running water, though the mud look never so black, there is ^{Chalk, &c}
no heart in it, except holpen by land-flouds, because there is
no salt in it; for salt is the strength of all dung; therefore let
it alone, unles to lay on a white ground, for mixing of earths;
for if you lay an hungry gravel on an hungry clunch, & con-
tra, they fertilize each other.

Also any sward plowed up, and thrown on the land, or laid
on heape till it be rotten: or making a dung-hill, and laying
stratum super stratum, a laying of street-earth, and a laying of
these turves, laying upon laying, till they be rotten, makes an
excellent compost for many years.

The burning of hawn upon the ground, commonly called
Devonshiring (because much used in *Devonshire*) is not unworthyly a little extolled of the Poet:

Georgic lib. 1.
Sape etiam steriles incendere profuit agros,
Atque levem stipulam crepitantibus urete flammis;
Sive inde occultas vires, & pabula terra
Pinguia concipiunt: sive illis omnes per ignem
Excoquuntur vitium, atque exsudat inutilis humor:
Seu plures calor ille vitam, & cœca relaxat
Spiramenta, novas veniat quæ succus in herbas;
Sen dura magis, & venas adstringit hiantes;

*Nō tenues pīcūia, nō pīcīus potēnsia Sōlis
Acīor, nō Bonā pēntrībile frīgū adarā.*

To this give me leave to add a little of mine own experience. About the year 60², was such a frost, without snow, that it killed all our wheat: one M^r. Hen^r of Norb-Mynn had but two bushels growing of thirty acres sown. I sowed most part of mine again with barley in March, onely I had one head-land that looked most gloriously, covered green all over, as thick as grass in a meadow. I thought this might do well enough; let it alone till mid-May, then I began to mistrust by the blade, that all were but wild-oats. I digged up a turf as broad as my hand, wherein I found two wheat-corns, but 200 wild-oats, grown to that height all of one depth perfectly upright, as thick as they could stand one by another, just as letters are set in a frame to print a book. How they should come there at all, the Lord knows, much more in that manner. Well then, I saw there was no hope of a crop of wheat, and thought it too late to sow barley, neither had I any left, save a little tiny-head-corn, that I took & steep'd it a day and a night in water of an hors-dunghill. I sowed all that head-land, but one quarter of it, which had been troden with horses turning upon it in wet weather after it was sown. This barley, when harvest came, was the first I had ripe, clean without tares, or any other soil, as thick as it could stand, and every way the best that ever I had growing: but the wheat not worth the reaping, wherefore I let it stand till harvest was home, but had I mowed it green, it had been the best hors-meat of all other, as afterward I found in wild-oats and beans. When harvest was home, on a fair day, the windes sitting right, I set fire on it: but he that had seen that fire, and heard the noise, and had not read Virgil before, would have said certainly Virgil was at that fire before he made his book, and that there he learnt it, or else he could never have found out such an Epithete, as --- *Crepitansibus ureo flammis:* for whether it was by reason of the wild-oats, in every hors-footing made by turning on in wet weather, or otherwise,

there

there was such a noise as if twenty muskets had gone off at once, insomuch that an herd of cattle being a quarter of a mile off, seeing the fire, and hearing the noise; as if they had been out of their wits, or rather stark mad, set up also such a running, roaring, bellowing, and howling, that it made me to run as fast as they, to hear such an hideous noise, and the fire so violent, the weather being dry, and the whole crop being still there which was very great, and the wind full in one end, and whistling, insomuch that all the ground for two or three and twenty pole long, and a pole and half broad, was all on fire at once: this past my skill to quench, neither would all the blankets in the Town have served the turn, if I had had them there. But that this was soon out, I think neither the *Sicilian Etna*, that throweth stones sixty miles, nor *Hesla* in *Iceland*, nor *Vesuvius* in *Campania*, that sends his ashes more than two hundred miles off; (or, if you will believe *Cassiodorus*, in the time of *Titus* and *Vespasian*, they flew into *Asia*, *Syria*, and *Egypt*: and lastly, breaking out again in the year 1632, *Cripinus miliaria centum auditus*: & did yon not hear this *crepitus*? certainly it was because either you were deaf, or not near enough) could present a greater terror. But notwithstanding all this, my wild-oats were not yet killed; and then I was vexed with my self, that I had not mowed them green for horsemeat: for out of every horse-footing, contrary to my hopes, I could take up whole yea-folds, that were never the worse for the fire, save only their smell. Then I filled my hand-kerchief and both my pockets with them, to carry home to my hoggs, hens, pigeons; but not a corn any of them would touch. All this was still worse and worse. About *All-Saints-day* following, there came a frost and a little snow, upon that there was so many flesh-crows, that you would have thought that there had been proclamations set up in all woods, groves, fields, and yards through the whole land to summon them thither; or whether that was their beacon when I burnt it, or no, I know not. These for a fortnight together so covered the ground, that you could not choose but say, it was far blacker then ink: for

this was of a double die, one of black crows, and another of black ashes. The frost breaking, those that they had not eaten they trod into the ground with their feet, so that by the later end of the moneth, no meadow could be thicker of green grass, then that was of green-oats. I plowed them in, and by *Candlt-mas*, it was green again; I plowed it again, then it lay till the later end of *April*, and was green again; then I steeped my seed as I did the year before, and sowed it with barley, and had a very good crop, and so killed the wild-oats.

Burning of queach, &c. The burning of queach also, in some ground, is exceeding profitable. And not onely the steeping seed in dung-hill water helpeth greatly, but also in lime and water, by reason that which gives it heart lies close to the root. Some also wash seed-wheat and rie in lime and water in the seed-leap in the field, and then sow it, and so no crows nor pigeons will ever touch it.

CHAP. XXXVI.

Of planting Willows.

IN stead of beetle and stake, or crow of iron, make you an Augre like a pump-augre, make it after this manner: Make a plate like a peel of a foot or fourteen inches square, well steeled, and turn it as an augre is turned; let it have a socket like a peel, but four-square, into which put a stake of good tough ash two foot long, and four-square, as the socket is, with a bar or hoop of iron about it at the top, to keep it from cleaving: let it be two inches square at the least upward, in which near to the top bore an hole; or else make a mortes to put in a cross piece to turn it by, and to take it out by, then enter it a little with your spade, as you do a carpenters wimble with a gouch, and then bore your holes; which in strong clay is an exceeding speedy way. Besides that, if the sets be not very great, you will have room enough to ram the moulds down to the bottom.

CHAP.

CHAP. XXXVII.

Of reducing wood-land to statute-measure, and statute
to wood-land.

I have severall times measured ground by statute, which should have been done by the eighteen-foot pole; but never the contrary. One amongst the rest was a close in *Hexton* in *Hartfordshire*, where three Copy-holders had each of them apart expressed in their severall copies, how much by measure, but not by what measure: thereupon it was taken for granted, that it must be Statute-measure. One of the three had held all in his occupation divers years together, and lying in stiches, & no banks between had plowed one amongst another. A and B would have theirs again. A must have so much on the East-field, B so much on the middle, and C the rest, for C would neither shew his copie, nor yet make known how much he should have. So I laid out each man his share accordingly, and took a plot of the whole. Still it runs in B his minde, that his part was not so good as it had been formerly, mistrusting that I had done him wrong in laying it forth; so that he acquainted the Lord of the Mannour with it, who demanded of him by what measure he had measured it: he answered by the Statute-pole; Then, quoth the Lord, there is the errour, the custome is eighteen foot, and was the measure taken in *Henry the eighth* his time. This being known and reduced, C shewed his copie, and there was not a pole difference in the whole thing: so I gave them direction to alter it without going to the ground. To do this there are severall ways. First a Statute-pole is sixteen feet and an half, or 33 half foot long, therefore 33 half-feet square is 1089 square half-feet in a Statute-pole: bat in an eighteen-foot pole, which is 36 half-feet square, are 1296: so then if you multiply your Statute-poles by 1089, and divide the product by 1296, you have the number of eighteen-foot poles, which divided by 40 gives you the roods, and vice versa. And thus six acres of Statute, which is

is 960 poles, multiply'd by 1089 makes 1045440, and that divided by 1296 gives 800 $\frac{1}{2}$ or $\frac{1}{3}$, which is five acres six pole $\frac{1}{3}$ of the 18 foot.

Likewise five acres of 18 foot is 800 pole; that multiply'd by 1296 produceth 1036800, which divideth by 1089, quotient 952 $\frac{1}{2}$ 1089 pole, that is 5 acres, 3 roods, 52 pole. And this is the best way. So that the analogy is thus.

As 1089. 1296 :: 800. 18 foot pole to 956. 1089.
id est, 5 acres, 3 roods, 52 pole 1089. And as 1296. 1089 ::
 800 statute, to 672 $\frac{1}{2}$, *id est*, 4 acres, 3 roods, 32 poles $\frac{1}{2}$. And this is your best way: and thus may you do with all other poles.

Another way is, if upon your scale you have two scales, one of 11 in the inch and another of 12: if you lay down st
measure by the scale of 12, and then measure the same plot by the scale of 11, it gives you the wood-land measure, and likewise on the contrary.

C H A P. XXXVIII.

To finde any scale that a plot is made by, the content being known.

Suppose any scale, as 10, and measure it by that; now if by measuring it by the scale of 10, it comes to but 23 acres 82 parts: but it is truely 34 acres, 31 parts: therefore finde a mean proportional between these two; which, because the work is somewhat difficult, I will therefore shew you the manner of it.

First multiply 32. 82. by 34. 31. as here it is set down: so you see it produceth 817 12642. And because there are four figures in the Fracti
ons of the two Factours; therfore there

34.	31.
23.	82.
<u>68.</u>	
62.	

are

are also four in the product; so the whole number is 817 and 2642, the Fraction, the square-root is 28 1. 39, which is the mean proportional desired; then say, At the lesser of the two numbers, *viz.* 23, 82, is to your mean proportional 28. 39: so is your supposed scale to 12, the true scale, as 23. 82. 28. 39 :: 10. 12. See the work.

28	1. 39	3326
10		565
28590	(12)	2845
2382		30142
4770		3708
2382		43664
4764	6	4478

But because there is too much difficultie to finde it this way, and so little by the line of numbers, and so soon done, and is exact enough; therefore by it divide the distance between 23, 82, and 34, 31. into two equal parts; and the compasses will fall at 28, 39. then because 28, 39. is more than 23, 82. therefore set one foot in 10, and turn the other upward; it will fall at 12, the scale desired.

CHAP. XXXIX.

Of making an Index or Table, whereby readily to finde out any ground, that ever you have measured, and to tell the quantity of them an hundred years after, and draw a plot of them without going again into the field.

I Shewed before (in Chap. 2.) the manner of keeping your field-book; by help of that, and this, you may readily obtain your desire.

All the field-books, that ever you fill with notes, page
P them

them all, writing at the top of each page the name of the Parishes, or Parish, wherein the land hath contained in that pages; and at every beginning of a new man, set downe his name, and likewise at the beginning of every new field, for long, or parcell in a furlong, let downe the name of the close, fields, furlong, or parcell. Also write on the cover of your first book, A, on the fore end, B, on the sherd, C, &c. Then reserve four and twenty pages at the end of your first book, A, which shall not be paged, or else makes little benefit by self: and on the cover thereof write I, M, D, E, X, and on the top of each page, write A, B, C, &c. in Alphabetical order. Then under each severall letters write: first the Towns begining beginning with that letter, secondly, The mans name, for whom you measured; thirdly, The books name, in which you wrote it, and fourthly, The pages: either all of them, or, at least, the first and last. And whereas you may think this way will not be so beneficiall to you, as to go measure it again; for that you may do as you see good: you need not finde it, unless you will. Besides that, you deserve pay both for surveying, plotting, and notes; as if you had measured it. And if you will measure it again, these notes will do you no hurt. See an example:

Purton. *Norton.* lib. C. pag. 31, 32, 33, 34.

Panchurch. *Rob. Audley.* lib. B. pag. 64. ad 76.

Putford. *Tho. Dennis.* lib. K. pag. 97. ad finem.

Refer

Refer this following to pag. 85, line 13.

But if you would bring water to your house from a conduit, where you desire to place a cock as high as you can; and that without Instruments: First, begin at the conduit, and dig a trench near a foot deep there; but as you go further off, let it be still shallower for five or six pole in length, more or less, according to the fall of the ground; so that the water may but just follow you, and when it begins to run over, there stay it, and begin a new depth as afore; but be sure the fall of it be down-right like a stair, and so go on till you come where you would be: then add the fall at the conduit, and all your stairs together; and so high may you set your cock above the level of your trench.

F I N I S.

P 2 An

C. An Appendix to my

Faithfull Surveyour

VII have, in the book it selfe, spoken of measuring such things, as are measured by observing Instruments, as the Pandorum, plain Table, Quadrant, Theodelete, Circumferentor, &c. or of measuring of land, taking of Altitudes and Distances, taken by the chaine. here we will speak of such superficies as are done by a two foot rule, as board, glas, pavement, wainscot, and of solid, as stone and timber; forbearing those things, that seldom, or never, come in question, as globes, regular bodies, and the like. First, Because land-measure and those seldom meet together in one man; Secondly, Neither would I have the book to be of two big a price; and Thirdly, Because my little time I have, hath need to be spent to the best advantage for the common good.

CHAP. I.

Of making the Rule.

First, I would have the Rule, (whether it be of box, or of bras, whether joyned in the middle, or streight out,) to be just two foot long by some standard of bras, kept by the Clerk of the Market and not, as I have seen some, that have been half an inch too long. Let it be an inch and an half broad at the least, and a third part of an inch thick with a square stroke struck round about it just in the middle of the length thereof. Let one edge be besild off: which serves that if you have occasion to draw lines with a pen, if you turn that side downward, you need not fear blotting: if your rule chance to be blackt with linke, if you rubb it well with sorrel, that will fetch it out. Through the midst of this besill strike a Gage-stroke: an another along the midst of the other edge: divide

divide the rest of this side, beside the besill, into eight equal parts with severall Gage-strokes. In the 4 next columnnes save one to the besill, you may place all the under-measure of this Table of board-measure following, which will not fall in a scale upon the rule, viz. all inches, halves, and quarters from one inch to six; if you will set ten inches in the first, the inches of the breadth of the board, in the column next unto the besill, the feet required to a foot forward at the breadth in the next, the odd inches in the third, and the quarters in the fourth. And adjoyning to this Table toward the middle of the Rule, in the first of those four columnnes, let one inch divided into ten equal parts, and each of those into halves, and each of those halves into five; or suppose them so divided: so is it divided into 100. parts of *Centimes*; from which inch you shall take off all your *Centimes* with your compasses, that are to be set in any of your scales.

For making the scale of board-measure.

Before you can make this scale, you must have one column, on the other side the Rule, next the besill, parted into three small parts with Gage-strokes, and divided in the middle of the length of the rule into two equal parts or feet; whereof divide one of them into ten equal parts, and each of them into ten more, and each of them suppose at least to be divided into ten other; so shall that foot be divided into 100. and this *Ganther* calleth foot-measure: which must be reckoned both wayes, first from the beginning of the rule to the middle, thus, 1, 2, 3, &c. and backward again, and thus, 11, 12, 13, &c. and because the other foot makes ten of these inches, and these ten make twelve of them, therefore divide the other foot into twelve equal parts or inches, and each inch into eight parts, and number it from the end toward the middle with 1, 2, 3, 4, &c. but from the middle to the end with 13, 14, 15, &c. and this he calleth inch-measure. By help of this inch-line and the inch aforesaid, and by help of your Tables for board and timber-measure, are made your scales for board and timber-measure. And this Table of board-measure

is thus made: First, for all whole inches divide 144 by the inches of the breadth, and you have the inches forward to a foot. If any thing remain after division, it is the Numerator of a common Fraction, whose Denominator is the Divisor; to which remain annex two ciphers on the right hand, and divide again by the same Divisor, and you have the *centesims* desired. *Example.*

Let a board be seven inches broad, I desire to know how many inches forward makes a foot. Divide 144 by seven, it gives twenty inches; or one foot eight inches $\frac{2}{7}$. Now to bring $\frac{2}{7}$ into *centesims*, annex two ciphers to the remain four, it makes 400: which divide again by seven, it gives $\frac{56}{400}$. But for half-inches reduce the breadth into an improper Fraction, as $6\frac{1}{2}$ is $\frac{13}{2}$; then multiply 144 by the Denominator 2, it gives 288: so that you must always divide 288 by the Numerator, or number of half-inches of the breadth of the board, which is 13; so have you 22, or one foot, ten inches, 15 *centesims*. But if your breadth be an odd quarter, or three quarters: First, reduce it into quarters, and divide 576 by it: so $6\frac{1}{4}$ is 27 quarters, therefore divide 576 by 27, it gives 21 inches; or one foot, nine inches, $\frac{2}{7}$, or 33 *centesims*. The Table followeth.

A Table shewing how many feet, inches, and centesims of inches forward are required to make a foot of board-measure at all breadths, both whole inches, half-inches, quarters, and three-quarters, from one inch in breadth to 36 inches.

	Quar. feet, into cent.	Quart. feet, inche cent.	Quar. fath. cent.	Quar. fath. cent.	inch cent.	
Board,						
small	10 12 19 21	8 10 11 12	6 9 10 12	6 9 10 12	1 1 1 1	
1 0 12 19 21	8 10 11 12	6 9 10 12	6 9 10 12	6 9 10 12	1 1 1 1	
1 0 12 19 21	8 10 11 12	6 9 10 12	6 9 10 12	6 9 10 12	1 1 1 1	
1 0 12 19 21	8 10 11 12	6 9 10 12	6 9 10 12	6 9 10 12	1 1 1 1	
1 0 12 19 21	8 10 11 12	6 9 10 12	6 9 10 12	6 9 10 12	1 1 1 1	
1 0 12 19 21	8 10 11 12	6 9 10 12	6 9 10 12	6 9 10 12	1 1 1 1	
3 6 10 29	3 1 4 46	3 9 14	3 6	3 6	33	
2 0 6 0 0 9	0 1 4	16 9 0	23	6	26	
1 5 0 4 0	1 1 3	56 1 8 87	1	6	19	
2 4 9 60	2 1 3	16 2 8 73	2	6	13	
3 4 4 30	3 1 2	77 3 8 37	3	6	6	
3 0 4 0 0 10	0 1 2 40	17 8 41	24	6	0	
1 3 8 31	1 1 2 5	1 8 32	1	5	94	
2 3 5 15	2 1 1 76	2 8 22	2	5	88	
3 3 2 40	3 1 1 35	3 8 12	3	5	82	
4 0 3 0 0 11	0 1 1 9	18 8 0	25	5	76	
1 2 9 88	1 1 0 80	1 7 81	1	5	70	
2 2 8 0	2 1 0 51	2 7 78	2	5	65	
3 2 6 31	3 1 0 25	3 7 68	3	5	59	
5 0 2 4 80	12 0 1 0 0	19 7 58	26	5	54	
1 2 3 41	1 0 1 1 76	1 7 48	1	5	48	
2 2 2 18	2 0 1 1 52	2 7 39	2	5	43	
3 2 1 4	3 0 1 1 29	3 7 29	3	5	38	
		Quar. Inch. Cent.				
6 0 2 0 0 13	0 11 8	20 7 20	27	5	33	
1 1 1 1 4	1 10 87	1 7 11	1	5	28	
2 1 10 15	2 10 67	2 7 2	2	5	24	
3 1 9 33	3 10 46	3 6 94	3	5	19	
7 0 1 8 57	14 10 29	21 6 86	28	5	14	
1 1 7 86	1 10 11	1 6 78	1	5	11	
2 1 7 26	2 9 93	2 6 69	2	5	5	
3 1 6 58	3 9 76	3 6 62	3	5	1	

<u>Q.</u>	<u>I.</u>	<u>C.</u>									
29	4	97	31	4	65	33	4	36	35	4	12
1	4	03	1	4	61	1	4	33	1	4	9
2	4	89	2	4	38	2	4	30	2	4	6
3	4	84	3	4	34	3	4	27	3	4	3
30	4	80	32	4	50	34	4	24	36	4	0
1	4	76	1	4	46	1	4	21			
2	4	73	2	4	43	2	4	18			
3	4	69	3	4	39	3	4	15			

Now to place this Table upon the rule, divide the second, third, fourth, and fifth columns next to the besill, at one end into small squares that may hold two figures a piece, in which set over-most the inches of the breadth, in the second the feet required in length, at each inch, half inch, and quartern. In the next the odd inches, and in the next the odd centesmes : and this you must do to six inches, you may do it to ten inches if you will. Then at the end of ten inches, set one inch divided into ten equal parts, and each of them into halves, and suppose each half into five, so will it be supposed to be divided into an hundred parts, as before. Then from six inches to 36 you shall set all in the column next the besill, with small strokes, after this manner : First, I begin with six inches and a quarter, to which I finde in the Table there belongeth one foot, eleven inches, four centesmes, that is eleven inches, four centesmes from the middle cross stroke of the rule. But because my compasses will not reach so far, I onely take 36 centesmes from the former inch, which makes it just two foot from the same end, which I set the under measure at.

Another example let be $9\frac{1}{4}$, for which I finde in the Table one foot, three inches, 36 centesmes. First, I take with my compasses 36 centesmes from my inch of centesmes, and prick it down upon a line upon a paper. Also with my compasses I take

take three inches in the foot-line of inch-measure on the other side of the Rule: set that distance also on the paper at the end of the 56 Centesme in the same line; then take with your compasses the whole length of both, set one foot in the middle-cross-line of the Rule, and in the said scale, and the other toward the beginning of the Rule, and it gives the length correspondent to nine inches and $\frac{1}{2}$, from the stroke to the end of the Rule. Thus do with all the rest, marking each whole inch with its proper number to 24, also 30, and 36.

And now, before we proceed to shew you the making of the Table of timber-measure, we will first shew the measure of boards.

CHAP. II.

Of measuring of boards with the Rule.

There are divers ways of measuring of boards: of which the fundamental way is this; 12 inches in length, and $\frac{1}{2}$ in breadth, that is twelve times twelve, or twelve inches square, which is 144 inches, make a foot of board: therefore multiply the inches of the length of the board by the inches of the breadth, and divide the product by 144, you have the content in feet. If any thing remain, divide it by twelve, it gives the odd inches, or twelve parts of a foot: for an inch is the twelfth part of a foot, let the foot be what it will. *Example.*

Let a board be 13 foot five inches long, that is 162 inches long, and nine and an half broad, these multiplied give 1529 and an half, which divided by 144, give ten foot, & 89 square inches and $\frac{1}{2}$ remains, which divided by 12 is $7\frac{1}{2}$ ferè inches of board. Secondly, If you multiply the length in feet, 13 feet 5 inches, by the breadth in inches $9\frac{1}{2}$: first, 9 inches by 13 foot, is 9 foot 9 inches; & half of 13 is $6\frac{1}{2}$, and 6 square inches; and 9 times 5 inches is 45 square inches; and half five inches is two and an half square inches. First then, add all your inches together, 45, 6 and $2\frac{1}{2}$ make 53 and $\frac{1}{2}$, which divided by 12, gives 4 board inches, and $5\frac{1}{2}$ square inches, or half a board inch

inch ferē. Now add these 4 inches to 9 and 6 inches, they make 19 inches, that is, one foot, seven inches, to which add 9 foot, it gives ten foot, seven inches $\frac{1}{2}$ ferē, just as afore: and both those ways are performed by any common Rule that hath no board-measure on it. Hence then is discovered this errour, that if a board be nine inches broad, to take 15 inches forward to make a foot, that is so much more then twelve, as nine is less, whereas our Table saith you must take 16, is a false way: for nine times 15 is but 135, which wants nine square inches of 144, and is always the square number of half the difference of nine and 15 equally distant from 12, whose square is 9. So likewise 8 and 16 being multiplied make 124, which wants 16 of 144: and because they are equidistant from 12, and their half difference is 4, therefore their product is less by sixteen, the square number of four, then the square of twelve.

3. A third way of measuring board is by this rule, Measure the breadth of the board; if it be less then six inches, your Table of under-measure will shew you how much forward you must take to a foot forward. If it be broader, and under 36 inches, then the strokes on your scale give it.

4. Some measure all the breadths of the boards with a line, then stretch the length on a block, and so measure the breadths of all the stock at once, and then measure the length of a board, then multiply the length in feet and parts, by the breadth in feet and parts: So suppose the breadth of all the boards is ten foot, nine inches, and the length 154 inches, instead of nine inches, I take $\frac{1}{2} \frac{1}{4}$ of a foot, and instead of four inches I take $\frac{1}{3}$, or $\frac{1}{4}$ one inch, and the work will be thus, and it makes 164 feet $\frac{1}{4}$, 1 inch and an half.

And this is a very good way in ease a block be hewn eight-square, before it be sawn: which if it be fit for boards, it is pitty it should be hewn any other way; so will it be no los of timber, the boards will be all streight-edged. If it be sold in timber, and measured as eight square,

15. 4. 1.

10. 2. 4.

150.

2. 2.

248.

7. 248.

3. 24.

164. 2. 4. 1. 2.

(as

(as shall be shewn) there will be no loss either to buyer or seller.

C H A P. III.

Of making of a Table of timber-measure for square timber, to make the scale of square timber-measure by:
as also the under-measure.

First know that a foot of timber is twelve ipches every way breadth, length and thicknes, and therefore conteineth 1728 square inches, for 12 times 12 is 144. that is, a foot of board or a *superficies*, and twelve foot of board make 1728 inches; therefore to proceed to the Table. First, For whole inches: square the square of the piece, that is, multiply the square by it self, and by that product divide 1728. *Example.* Suppose the piece be 8 inches square, the square of 8 is 64, by which divide 1728, it gives 27 inches, or two foot, three inches. But if you have odd half-inches, then you must reduce as before all your inches* into half-inches, or an improper Fraction, by whose Denominator (which will always be 4) multiply 1728, it gives 6912, which must always be divided by the Numerator of the Fraction. Suppose the square given be $6\frac{1}{2}$, that squared is $42\frac{1}{4}$ which reduced is 169 quarters; by which 169 divide 6912, it gives 46 inches, or 3 foot 4. inches ninety *Centesmes*. Again if the square be of odd quarters or $\frac{3}{4}$ you must work as before, and then your dividend will be 16 times 1728, that is, 27648. *Example.* Let your square be $6\frac{3}{4}$, that squared is $45\frac{9}{16}$ sixteenths: which reduced into 16 parts by multiplying 45 by 16 and adding 9, it gives $7\frac{19}{16}$ sixteenths. Therefore divide 27648 by 729 it gives 7 inches, or 3 foot, 1 inch, 92 *Centesmes*.

Here followeth the Table of timber-measure.

Q. 2

Inch

Inch	feet.	inch.	cen.	Inch	feet.	inch.	cen.	Inch.	Inch.	C.	Inch.	Inch.	C.	
square.	I	I	I	square.	I	I	I	I	I	I	I	I	I	
1 0 144	0	0	8	0	2	3	0	15	7	68	122	3	57	
1 92	1	92		1	2	1	39	1	7	43	1	3	49	
2 64	0	0		2	1	11	91	2	7	19	2	3	41	
3 47	0	24		3	1	10	57	3	6	97	3	3	34	
2 0 36	0	0	9	0	1	9	33	16	6	76	23	3	27	
1 28	3	33		1	1	8	19	1	6	34	1	3	20	
2 23	0	48		2	1	7	14	2	6	33	2	3	13	
3 19	0	60		3	1	6	25	3	6	16	3	3	6	
3 0 16	0	0	10	1	1	0	3	28	17	5	98	24	3	0
1 13	7	55		3	0	1	44	1	3	81	1	2	94	
2 11	9	6		2	0	1	367	2	3	64	2	2	88	
3 10	2	88		3	1	2	95	3	3	48	3	2	82	
4 0 9	0	0	11		1	2	28	18	5	33	25	2	76	
1 7	1	67		1	1	1	65	1	5	19	1	2	71	
2 7	1	33		2	1	1	6	2	5	5	2	2	66	
3 6	4	75		3	1	0	51	3	4	91	3	2	61	
				Inch.	Inch.	C.		Inch.	Inch.	C.	Inch.	Inch.	C.	
5 0 5	9	12	12		32	0		19	4	78	26	2	56	
1 5	2	69		1	11	57		1	4	66	1	2	51	
2 4	9	12		2	11	6		2	4	53	2	2	46	
3 4	4	26		3	10	63		3	4	43	3	2	41	
6 0 4	0	0	13		10	29		20	4	32	27	2	37	
1 3	8	23		1	9	82		1	4	21	1	2	33	
2 3	4	89		2	9	48		2	4	11	2	2	29	
3 3	1	92		3	9	14		3	4	1	3	2	25	
7 0 2	11	27	14		8	82		21	3	92	28	2	21	
1 2	8	88		1	8	52		1	3	83	1	2	17	
2 2	6	72		2	8	22		2	3	74	2	2	13	
3 2	4	77		3	7	90		3	3	66	1	3	9	

In.	In.	C.	In.	In.	C.	In.	In.	C.	In.	In.	P.	C.
29	2	6	31	1	80	33	1	59	35	1	41	
1	2	2	1	2	77	1	1	50	1	1	39	
2	1	99	2	1	75	2	3	34	2	1	37	
3	1	95	3	1	72	3	1	52	3	1	35	
—	—	—	—	—	—	—	—	—	—	—	—	—
30	1	92	32	1	69	34	1	49	36	1	33	
1	1	89	1	1	66	3	1	47	1	1	31	
2	1	86	2	1	64	2	1	45	1	1	29	
3	1	83	3	1	61	3	1	43	1	1	27	

To place this Table on the Rule.

Begin at the other end of the Rule taking those 4 columns next the thick-edge save one, and divide them into little spaces, as you did for board-measure, setting on them all the under measure to 8 inches and an half square, yet you may do it to 12 inches, if you will, setting the square inches of the block in that column next save one to the edge: then the feet required to make a foot forward in the next: then the odd inches in the next to that, and the Centesimes in the last of the 4. Then from 8 and $\frac{1}{2}$ to 36 you may take off your inches from your line of inch-measure, and your Centesimes from your inch of Centesimes, as you did in board-measure, and place it backward or forward, according as it shall be more or less than a foot.

C H A P. IIII.

Of measuring solids, as stone, timber, &c. and first of square timber.

For measuring all kind of solids the fundamental or general way is to multiply the inches of the breadth by the inches of the depth, and that product by the inches of the length, and divide the last product by 1728. This is so plain, it needs no example: and this is the best way for stone of all other.

2. A second way of measuring square timber is by this Ruler. Having the square of the piece given look on the Rule, and see how often you finde the length required at that square between that and the end of the Rule in the length of the block, so many foot of timber is in that block.

*To finde the true square of a piece broader one way
then another.*

But to finde the true square of the piece, multiply the breadth by the depth, and from the product extract the square-root.

As let the breadth be eight, and the depth 14, these multiplied make 112, whose square root is $10\frac{1}{2}$, according to which square you must measure the piece. Which disproveth a common error; which is this, To add both sides together, and to take $\frac{1}{2}$ thereof for the square: for so 8 and 14 make 22, the half thereof is 11. And although there seemes but small difference, viz. less then $\frac{1}{2}$ an inch between their numbers or roots $10\frac{1}{2}$ and 11: yet between their squares there is no less then 9 inches difference, for 11 times 11 is 121, but 8 times 14 is but 112.

3. Now therefore because every Carpenter cannot extract the square-root, and to them that can do it, it is but a slow way: and thirdly we never set any scales of timber-measure upon Rules, but for inches, halves and quarters: take this for the best way of all other, where there is such difference of the sides measure it first that false way, then take out of it always a square piece of $\frac{1}{2}$ the difference of the sides, quite through the block; so in our example 8 and 14, their difference is 6, the $\frac{1}{2}$ thereof is 3: therefore take a piece of 3 inches square through the length of the block, for that 3 squared gives 9, which is the difference between the square of it and the rectangle of 8 times 14.

C H A P. V.

Of round timber.

Because to every circle there belongeth 3 squares, first the square without the circle, or the square of the diameter; secondly, the square equal to the circle, not in Peripherie, but in the *area*; for if the *area* of a circle of a mile round, and a mile about in a square be compared, we shall finde the square to contain just 40 acres, whereas the circle of the same Peripherie containeth 50 acres, 3 roods, 25 poles $\frac{5}{12}$; and thirdly the side of the square within the circle: therefore we will first shew the manner of making these 4 scales, and then the measuring of round timber: yet before we shew the making of them our best way is to take *Virgil's* advice, and to do as he doth with his Bees.

Principia sedes apibus statioque petenda.

So before we shew the making of them we will first finde out a seat for each of them, and then the making of them one after each other. First, in the beginning of the first chapter we shewed that we would have one of the edges on one side besild off: and the rest of that side divided length-wise into eight equal columns with 7 Gage-strokes upon the besill, $\frac{1}{2}$ the length of the Rule, you may set a scale of 20 in the inch dividing each inch into halves and quarters. Numbring each half-inch with 10, 20, 30, &c. save that half-inch next the beginning, which must not be accounted for any of the tens: but that must be divided into ten equall parts by it self, to take the odd inches above even ones, that any round block or circle is about.

Besides this, you have three other scales that are for round measure, that shew the three squares belonging to the circle: and any of these four being known, all the rest are known only by taking the number thereof upon its proper scale with your compasses, and apply that distance to the scale proper to the thing desired: and these three scales for these squares are one

one for the Diameter, or side of a square without the circle, and that each side thereof toucheth the circle. Another is the side of a square within the circle, or of the chords of 90 degr. and the other is a side of a square, whose content is equal to the content of a circle. For *Example*. Let a block be girded about with a nealed wyer, and then that wyer laid along upon the block, being found to be 88 inches, I set one foot of the compasses in 80 of the said circle scale, and the other foot in 8 of those 10 odd parts next the beginning of the Rule, reckoned from ten upward, being the contrary way to the other 80. If then you desire to know the Diameter of the circle, or side of the square including the circle, you shall finde it just 28 inches, by setting one foot of the compasses in 25 of the Diameter scale, and the other will fall in three odd parts, which added make 28: for all these three last scales must be divided into fives, and numbred with 5, 10, 15, &c. and five odd ones above, at the beginning. Likewise if you apply the same wideness of the compasses to the scale of the square within the circle, that is, to the square, that a block being round will be, being hewed just to the four edges: then set one foot of the compasses in one of those great divisions by fives, so that the other may fall amongst the odd small divisions, and it gives you $19\frac{1}{4}$ fere.

And lastly, if you apply the same wideness of the compasses to the scale for the square equal, setting one foot in the great divisions, so that the other may fall in the five odd small ones, it gives 24 and about $\frac{2}{3}$.

And in like manner if any of the other three scales be given, as if the Diameter 14 be given; if you take 14 upon the Diameter, and carry that to the circle; it gives 44; if to the square equal, it gives about $32\frac{1}{3}$, and so of the rest.

C H A P. VI.

Of the proof of these scales by Arithmetical calculation.

First, for the circle-scale, that needs no proof, so that it be truly divided : for that is the basis, on which the other are built, or scale, by which they are made.

Secondly, For the Diameter *Archimedes* gives this rule. Multiply the Circumference by seven, and the product divide by 22, so have you the Diameter: so on the contrary. Thus our circle 88, multiplied by seven, gives 616, which divide by 22, quoteth just 28, as afore.

Thirdly, For the square within the circle this is the rule. The square without the circle is double in content to the square within. Or thus, The content of the square within the circle is to the content of the circle as 7 to 11: First, therefore by the content of the square without, we found the Diameter, or side of the square to be 28, that squared or multiplied by it self is 784, the content thereof. Therefore the content of the square within is but $\frac{1}{2}$ 784, that is, 392, whose square-root is $19\frac{11}{39}$, as afore. Secondly, by the content of the circle: for which *Archimedes* saith, half the Diameter multiplied by half the Circumference gives the content, so 44, the half of the Circumference, multiplied by half the Diameter 14, gives 616, the content of the circle. This therefore multiplied by seven, makes 4312, which divided by eleven gives 392, just as afore.

Fourthly, For the square equal to the circle, having by this last rule found the content of the circle to be 616, we need but extract the square-root thereof, which is $24\frac{62}{39}$, which doth discover a most monstrous, and a most gross error in measuring round timber, of which hereafter.

C H A P. VII.

Showing the manner of placing these upon the Rule.

First, To set out the Diameter, you may take the nether part **F** of the third column of the besil'd side, to set it on from the middle square stroke of the Rule. Then Gunther (in his *Use of the line of numbers in broad-measure, Prop. 11.*) hath this proportion. Having the Circumference of a circle, to finde the Diameter: As 3143 to 1000, so is the Circumference, suppose it 47 $\frac{1}{13}$ to the Diameter 15: so that if you take 47 $\frac{1}{13}$ in your circle-scale, and set in that column from the middle square downward, so shall you set out 15 in that distance, run that distance as oft as you can to the bottom of the Rule, which will be 4 times more, divide each of them into 3 equal parts, and the uppermost third into 5 equal, and number all the other great parts, save that with 5, 10, 15, &c. or if you will you may double 47 $\frac{1}{13}$, that is 94, 26, and take it from the circle-scale, set it there they will be 30; then half it, and they will be 15, then third it into fives.

2. To finde how to proportion the square within the circle by the Diameter. Let the Diameter be the *Radius* 1000, then will the chord of 90 degrees, which is the side of the square included, be the natural sine of half 90: viz. 45 degrees, the sine whereof is 707, therefore then because I would divide my scale into even sines, if therefore I take 7 times 5, that is 35, the proportion will be 707. 1000 : : 35. 49 $\frac{1}{2}$ 50. or 49 $\frac{1}{2}$: therefore if you take 49 $\frac{1}{2}$ on the Diameter, and set it on the scale of chords, and divide it into 7 equal parts, and that part next the end into 5 small parts, numbring all but that with 5, 10, 15, &c. you have your scale of chords or square within the circle. Or (if you think it troublesome to divide it into 7 equal parts) you may take 6 times 5, that is 30. and say 707. 1000 : : 38, 42 $\frac{1}{43}$, so then you may take 42 $\frac{1}{43}$ of the Diameter, and set on your scale of chords, and then divide each of them into halves, and each half in to 3 parts.

Other-

Otherwise thus, The content of this circle according to Archimedes is just $\frac{1}{3}$ the content of the square of the Diameter. Suppose the Diameter 24, the square thereof is 576, the half whereof is 288, the root whereof is 17 feet, then say, If 17 in chords require 24 Diameter, what shall 40 in chords, or any other even number of fives? Answer, 56 $\frac{1}{3}$; therefore take 56 $\frac{1}{3}$ of the Diameter, and set it in the scale of chords, which because it gives 8 times 5, first divide it into halves, then into quarters, then into eights.

3. It may also be made by this Rule of his, The area of the square within the circle is to the content of the circle as 11 to 7, so that the circle being known, the content is thus found: $\frac{2}{7}$ the Diameter multiplied in $\frac{1}{2}$ the Circumference gives the content of the circle, which if you multiply by 7, and divide the product by 33, it gives the content of the square within; whereof take the square-root, and you have the side desired; therefore $19 \frac{1}{2} : 8.88 :: 20.88 : 9$, or as Mr. Wingate hath it (in Problem 33. of his Appendix to his Rule of Proportion) $225 : 1000 :: 20.88 : 9$. So that take 88 $\frac{1}{9}$ from the Circumference and set it on this scale, and divide it into four fives, and this scale may be set on the lower half of the besid' edge.

4. Having the content of the Circumference, to find the side of the square equal. Take the square-root thereof: so we found before that the Circumference being 88, the content is 616; whose square root is $24 \frac{1}{49}$, that is more than $24 \frac{1}{3}$: or more easily, because, as Gunther hath it, the Circumference is to the side of a square equal as 1000 to 282, therefore say, $282 : 1000 :: 20 : 70 \frac{1}{9}$. Therefore take $70 \frac{1}{9}$ of the Circumference, and set it in the scale of the square equal, it gives 20 of that scale; with which distance set out all the twenties the side will bear, dividing each 20 into four fives, and the last into five little ones, and numbring them by five as afore: and this scale may be set in the over part of the third column nexte the square edge.

*Error in round timber to take a quarter of the circumference
and add to it the for the square.*

5. And here I must acquaint you with that monstrous error in measuring round timber which I spake of before; which is this, to gird the piece about, and to take the fourth part for the square thereof: as suppose the piece be 80 inches about, then by this account the square should be but 22 inches: whereas in the last section we found it to be above 24 $\frac{1}{2}$; whereby the full fifth part of the timber is lost to the seller, which notwithstanding the most of them know to be extreme false, by reason that when they have hewed it, they make a great deal more of it, then they did before it was hewed: But what is their excuse? Even this they say, That will scarce pay for the hewing, and it is but sap and bark. I answer, The goodnes or badnes of any thing is considered in the price; but neither in the measure nor the manner of measuring. I have seen a sack of fine seed, white wheat, sold for ten shillings a bushel, another of grey wheat at seven, sold the same day all to one man: yet he had no more measure of the course grey, then of the fine wheat. Secondly, In that they say, They had need have that for hewing: I say, They never hew what they rend to laths, pales, rails, plow-timber, cart-timber, wheel-timber, boles, trenchers, dishes, spoons, and infinite other, which they rend, and sell sap and all. Thirdly, When they do hew any timber, they leave it so wany, that (in Cambridge-shire especially) they leave it nearer round then square; and yet allow nothing for the wanēs: so that in all other things, whether sold by weight or measure, the buyer is to have the draught, though it be but in an ounce of pepper, in this he must want of his measure, and that no small matter; for they seldom hew nigher to square in this Countrey, then that the four wanēs are as broad as the four flats, all which are equal to a square piece of the breadth of one of those wanēs; & although those wanēs be less in some places then in other, yet will they be of no service so deep as the deepest wane goes. And what sense or equity is there, that in buying they should

should desire so much over-measure, and yet in selling it hewed sell so much short, as in buying? Hath not he that buyeth wane-timber, that the wanes run not freight, as much need, and as much reason, to have allowance for the wanes, and to have the knots and bark left on them for hewing, as you to have the fifth part and more, and yet never hew a great deal of it at all? Besides, you have a trick, when you buy round-timber with the bark on it, be it thick or thin, you will cut a notch round about the piece in the middle of the block, sometimes deeper then the bark, saying, That is but a boit: now you buying by measure, what right have you to the bark, which you measure not? yet when it is hewed, they that buy it must be content with air instead of timber. And yet further, I have known a Wheel-wright, that used to buy all his timber by the foot of fourteen inches every way to the foot, and to girdle it, and to take the fourth part for the square; thus did he over-reach the sellers, who thought it to be but a seventh part more then ordinary, and that he gave a penny or twopence more in a foot then others gave, they thought themselves well enough; whereas (poor simple fools!) they sold above two foot for one.

6. If you buy round-timber that is ordinarily taper, little or much, then you will be sure to gird it in the middle, or nearer the little-end, whereby you gain no small matter.

Lastly, How common a thing is it with Wood-mongers, to have one Rule to buy by, & another to sell by: one a quarter of an inch too long, another as much too short? And great pity it is, that considering there are so many abuses in measuring land and timber, it is not a whit looked into, whereas in all other things sold by weight or measure the abuses are punished by the Clerk of the market.

Now for correction of this false measure in round timber, committed by this way of taking the fourth part for the square, if it be a perfect Cylinder, and not taper, you may help your self by this Table, taken out of Mr. Stirrup's Plain-scale, or Carpenters new Rule, page 60, which you may draw into a

scale, as you do for square timber or board-measure; all but the first seven inches, which are under-measure, and set those 7 in four columns, between the two Tables of board and timber under-measure.

Squa. Inch.	Feet.	Inch.	Cent.	Squa. Inch.	Inc.	Gen.	Squa. Inch.	Inc.	Cen.
1	11	3	71	11	11	22	21	3	11
2	28	3	42	12	9	42	22	2	80
3	12	6	85	13	8	3	23	2	56
4	7	0	85	14	6	92	24	2	35
5	4	6	30	15	6	3	25	2	17
6	3	1	71	16	5	30	26	2	0
7	2	3	70	17	4	69	27	1	86
8	1	9	23	18	4	19	28	1	75
9	1	4	76	19	3	76	29	1	61
10	1	1	57	20	3	39	30	1	51

The use of this Table is thus.

Girt the piece about, and take the fourth part for the square, as if it were the true square, and therewith enter this Table; and it gives the feet, inches, and Centesmes required forward to make a foot forward at that false square. So 44 inches circle gives 11 inches for the fourth part, which in the Table gives 11 inches, 22 Centesmes, forward to a foot-square of timber. Or else having taken the Circumference with a nealed wier, and there made a twist, and measured the number of inches about, take off so many with your compasses, and apply that wideness to the scale of the square-equal, and you have the square you must measure it at. And because as I said before, that to hew a log for boards, the best way is to hew it eight-square, both for saving timber, and to have all the boards straight-edged; so neither shall the lawyers be paid for more then they saw, nor he that buieth the boards for the block it self, want, or have too much: we will now therefore give you

you one rule whereby to measure all equal-sided timber, so that it be not taper, how many sides soever it hath. First, finde the centre of your piece, and measure the semi-diameter thereof to the middle of one of the equal sides; then add all the sides together, multiply half thereof by the semi-diameter: so have you the content of the base, and that multiplied in the length gives the content of the piece. So in the figure the 8 sides are ten a piece, that is, 80; the half whereof is 40; the semi-diameter or perpendicular A B is 17, that multipliyed

by 12 makes 480, which is the content of the base, that is, one inch sawed off of the end of the piece. Then if either you multiply 480 by the inches of the length of the piece, and divide the product by 1728, you have the content of the piece. Orelse you may extract the square-root of 480, which is 22 ferē, and then measure it, as if it were 22 inches square. And thus may you measure all manner of timber, not taper, by measuring one inch at the end, as if it were land: then extract the root, and measure is as if it were so much square.

C H A P. VIII.

Of taper-timber, whether Conical or Pyramidal.

For such kinde of timber of either sort, measure it as if it were a whole Cilinder or Prisme, that is, First, finde the area of the base, and multiply it by the whole length, thus; Let a Prisme be four-square, the side 12, the area of the base is 144, and suppose the length 100, these multiplied make 14400. But by the Corollary of the 7th Prop. 12. lib. Euclid. every Pyramis is the third part of a Prisme, having the same base and altitude: therefore divide 14400 by 3, it giveth 4800.



4800 the content of the Pyramis. But suppose it be an imperfect Pyramis, that runs not to a point, but hath his top cut off; you shall then continue out the sides to a perfect Pyramis, by plotting it in paper, or else finde how much it wants by the Rule of three. *Example.*

The side of the base being twelve, the length of the piece fiftie, and the side there is six, so that there is six lost in fiftie; but the whole side of the base is but twelve, whence take six, six resteth. Then say 6. 50 :: 6. 50. and 50 and 50 make an hundred, as before. Now then for this little Pyramid, the side or Diameter of the base thereof being six, whose square is 36, the third part whereof is twelve, that multiplied by 50, gives 600, the content of the lesser Pyramid. Subtract this perfect Pyramid out of the great perfect Pyramid 4800, rests 4200, the imperfect Pyramis. And the reason, that holds between the Prism and Pyramis, holdeth also between the Cilinder and Cone, *Prop. 10. 12. Euclid.* Every Cone is the third part of a Cilinder, having the same base and altitude.

Of the Cone.

Let us now suppose a Cone also divided in length into 50 and 50, the greater Diameter at the base to be twelve, and six in the middle. First, to finde the Circumference to 12, the Diameter: 12 multiplied by 22 is 264, that divided by 7 is $37\frac{1}{7}$, the Circumference. Then multiply half $37\frac{1}{7}$ (that is) $18\frac{4}{7}$ by half the Diameter, (that is) six, it gives $115\frac{1}{7}$, the greater area, which multiplied by 100 the length, it gives $11514\frac{4}{7}$ the Cilinder, the third part whereof is $3838\frac{2}{7}$. the greater Cone, Now for the lesser, the Diameter is six, multiply it by 22, it is 132, that divided by seven, is $18\frac{6}{7}$ the base, which multiply by the length 50 is 942, the third part thereof is $314\frac{4}{7}$ the lesser Cone.

Now take $314\frac{4}{7}$ out of $3838\frac{2}{7}$, resteth the imperfect Cone 3520, which is almost twelve times as big as the lesser. Or, if you rather desire 12 and 6, the bases of the Pyramis, to be the sides of the square within the circle, as there they are, and then to see their dimensions: then first, if twelve be a side of

of a square within the circle, since the content, or square thereof, is but half the content of the square of the Diameter: therefore double the square thereof, and out of the double extract the square root, and you have the Diameter: so 12 squared is 144, that doubled is 288; whose square-root is 17 ferè, the Diameter.

Now to finde the Circumference, multiply 17 the Diameter by 22, *fact* 374. that divide by seven, it quoteth 53 $\frac{1}{7}$ the Circumference: then multiply halfe the Circumference 26 $\frac{1}{7}$ by halfe the Diameter 8 $\frac{1}{2}$, it gives the *area* of this base 227 $\frac{1}{4}$, which multiplied by 100, the length, gives 22707 $\frac{3}{4}$ the Cylinder, which divided by 3 gives the great Cone 75695 $\frac{1}{2}$. Likewise for the lesser square within, which is six, the square is 36, that doubled is 72, the square-root whereof is 8. $\frac{1}{2}$ ferè, the Diameter. Multiply 8 $\frac{1}{2}$ by 22, it gives 187, which divided by 7 gives 26 $\frac{1}{7}$ the Circumference, then multiply halfe 26 $\frac{1}{7}$ (that is) 13 $\frac{1}{4}$, by halfe 8 & an half (that is) 4 $\frac{1}{2}$, and you have 56 $\frac{172}{879}$ or $\frac{1}{72}$ ferè, the content of that *area*; which multiply by 50 the length gives 2835: the third part thereof is 945, the lesser Cone. Take this lesser 945 out of the greater 7569, resteth 6624, the imperfect Cone: So that the imperfect Cone is more then seven times as big as the little one.

The discovery of severall errors in measuring the Pyramid and Cone: and first of the Pyramid.

Some hold that to be true, To add the *areas* at both ends together, and multiply the i half thereof by the length of the piece, as in our example the *area* of the great end is 144, and the litt'e end nothing therefore half 144 (*i.e.*) 72 multiplied by 100 is 7200, but it should be but 4800, it is too much by 2400.

A second error is to take the *area* at the third part from the great end, as in this figure, at C and C, but there the square or side is 8, and the square number or *area* thereof is 64, which multiplied by 100 is 6400, too much by 1600.

A third error is to take the square in the midst of the piece,

as at B and B, where the side is 6, the area 36: that multiplied by 100 the length gives 3600, which is too little, for take 3600 out of 4800, the difference is 1200, a just quartern lost of the timber to the seller; so that it falleth near the middle between B and C, where it is 7 inches, for that gives 5900, yet there it is too much by an hundred.

Secondly in the Cone.

The common practise is to gird it in the middle, and to take the fourth part for the square. In measuring the cylinder, there was more then the fist part lost to the seller: but here that it is taper also, is a more intolerable loss. For if in the square Pyramid was lost a full quartern onely by reason of tapering: what will here be lost where two such errors combine in one to wrong a man? The Circumference in the midst of the piece is $26\frac{1}{7}$, the fourth part thereof is $6\frac{1}{4}$, which squared is $45\frac{1}{2}$ and that multiplied by 100 makes $4556\frac{4}{7}$, which taken out of 7569, there is lost to the seller 3013, which is almost one half thereof. Yet this goeth so far currant in all places, that he that contradicts it is scorned as a fool, and accounted as a knave.



CHAP. IX.

Of the making of four other lines on the flat-sides, whereof three are Mr. Gunthers lines, of numbers, sines, and tangents; and instead of the Meridian-line, which is onely usefull for Navigation, whereof Carpenters make little or no use, we have added a sextant of chords.

Although Mr. Wingate (in his book called *The Rule of Proportion*,) hath set down the making of them: yet for that he hath done them after another manner then here is shwon, neither will an ordinary Rule bear all those lines, we will therefore content our selves with Mr. Gunther's, & the line of chords onely. You shall divide the rest of the Rule beside the columns of feet & inch-measure before spoken of, into four other great columns, and divide each of them into two equal, and one of them into two also; so the great shall be for figures, the other 2 for strokes. These two of Mr. Gunthers you may set in the three middle columns, and the line of chords on the other outside.

First, for making the line of numbers.

I told you before that I would have you strike a stroke round about cros the Rule, I would also have another at each end of the Rule so close as possibly you can, onely to set one point of the compasses on. Then first set out your great division in each foot; viz. the thousands, if your number consist of four figures, or howsoever they are to be the left hand figures of any number, as 3 in 3 32. 346. 365 +. 37046, &c. and must be marked with the 9 digits in either foot, and the first last and middle-most with one, so that you may understand as many ciphers with it as shall be requisite, so that it may signifie 1. 10. 100. 1000. and then if one signifie 10 the next two will naturally signifie 20, but not always. Now to take and set the number 2 in his right place, take a Table of Logarithmes of absolute numbers, and look either the Logarithme of 2. 20. or 200. and

take the three next figures to the Characteristick, which are 301; then with your compasses take 301. viz. three inches, $\frac{1}{10}$ of a tenth part of an inch, and $\frac{1}{10}$ of a tenth part or *Centesmes* of an inch, and set one foot in the nether-most cross stroke, where you set the first one, and turn the other upward in the same column; and there set your 2 likewise with the same numbers, set one foot in the middle cross stroke where you set the middle one, and turn the other upward toward the uppermost one, and there set your 2 also: likewise, do with 3 whose Logarithme is 477. (*id est*) 4 inches, 7 tenths, 7 *Centesmes*, also with 4. And these figures for the making of this line we will call hundreds, the next subdivision tens, and the least *Centesmes*. But now because we will suppose your compasses will not well reach beyond the figure 4, whose Logarithme is 602, that is above 6 of those inches: therefore first, let us set on the tens so far on both feet, and then the rest of each foot afterward. Next set out each fifth tenth so far: because you must mark them with longer strokes, then each single tenth: so then you must not account the next of those fifths to 3 as 5. (for then you will account the one for nothing) but you must account it for 15, or 150. and so take the Logarithm thereof, which is 176. Likewise 25, or 250, is 398, which you must take with your compasses, and set in their places in both feet, and in like sort shall you do with all your single tens; accounting that next 1 not for 1, nor 2, but for 11. Or instead of taking them off with your compasses, strike out all the first foot with a fine small striking square of bras, laying it upon the Log. in the line of foot-measure, and then set out the other foot with your compasses by this.

Now for the rest of each foot, look out the Logar. of your numbers, and take the distance between it and the middle cross-stroke, and with that wideness set one foot in the upper 1, and where the other falls, there is the place of that number. *Example.* I would set out 70, the Log. is 845; I take the distance between it and the middle-stroke of the Rule, or the Arithmetical complement of it, 154, and set it both from the upper stroke

stroke and middle-stroke downward, and you set out seventy. But your over-foot may bear unites to 20, and from thence to 40, divide each tenth into five, and from thence to the end into two.

To make the line of sines, and tangentes.

First, you must know that neither the line of sines, nor tangents, enter the Rule till 35 minutes: where you see the two next figures to the characteristick 8, are both ciphers; there also the characteristick changeth from 7 to 8: for your characteristick sheweth what foot you are in: therefore since we reckon the minutes only by tens, our first number or division upon the Rule will be at 40 minutes of the first foot, shewn by the characteristick 8: for 9 is the last, and therefore belongs to the last foot; so that whereas you see that the Log. of one minute hath 6 the characteristick, & 4 63 the three next figures: therefore one minute would be above a foot and half before the entrance on the Rule, and likewise would the first minute of the tangents be. Now the Logar. of 40 minutes hath beside the characteristick 8 the three first figures 066 *forēt*: therefore take off a inch, 6 tenths, and 6 centimes, or 5 centesmes, and 7 millesmes, if you can ghuess so near, and set them from the nethermost cross-stroke at the beginning of the line of sines forward. And thus do for all under two degrees, be it sine or tangent: but from thence to sine 5 degr. 45 min. or tangent 5 degr. 43 min. (As suppose the sine of 4 degr. whose Logar. beside the characteristick is 843:) you shall take the distance between 8. inches, 4tenths, 3 cent. and ten inches, and apply that distance from the middle-stroke down-ward: and so of the rest of the quarter. But for all both sines and tangents in this first foot: you may by their Logarithmes strike them with a square, as you did the line of numbers.

Now for the upper-part shewed by the characteristick for all sines and tangents to 20 degr. as suppose the tangent of 20 degr. the Logarithme of 20 degr. tangent is 56: let it from the middle-stroke forward, but from thence to the sine of 90, and tangent of 45 degr. as the sine of 40, whose Logar. is

808; take the distance between it and the middle-cross-line, and apply it in the line of sines from the upper cross-stroke down-ward: then number all the whole degrees to ten, with 1, 2, 3, and after that in the sines with 20, 30, 40, &c. to 90, and the tangents with 10, 20, to 45, and back with 50, 60, to 80 degrees.

Lastly, for making the sextant of chords.

Set a pair of beam-compasses, with a beam of willow, deal, or lallow, near half an inch thick, and $\frac{1}{4}$ broad; make a little morte of good tough wood, with a morte in it, that the beam may slide in it to and fro, indifferently stiff, and in all places alike, with a short prick, or little piece of an aule-blade in one end, and another longer in one edge of the beam hard by the end, so long from the beam as the other point is. If it goeth not stiff enough to stand and tran with at any place, make the mortes a little the deeper one way to put in a wedge; or else help your self with a screw-pin, then go to some smooth loft boards, opening your compasses to $23\frac{1}{2}$ inches, and with that wideness tran an arch, that may be two foot long at the least, and with each foot of the compasses make a prick in the said arch, and set it likewise upon the Rule; then diuide that space in the arch into two equal parts, which will be 30 degr. a piece, and each of them into three apiece, which will be 10 degr. apiece, and each of them into two, which will be five apiece, and each of them into five simple ones. Then take them off from the floor, and set them on the Rule, one after another, and number them with 10, 20, 30, 40, 50, 60, and this will be wonderfull beneficial in Dialling, and also in many other things, as to divide a circle into any number of equal parts, or to make an angle of any number of degrees, or to finde the quantity of any angle, and so by the line of foot-measure you may also divide a streight line into as many parts as you will.

Now as I have shewed the use of all the lines on the other side of the Rule, and also of both the out-side lines on this side; so for the other three I must content my self to shew you

you the use in general : for if I should descend to particulars, all the paper in Cambridge would be too little to hold them. First therefore, you see already, that as by the line of foot-measure, and Table, of Logarithms these lines are made, so may you by these lines finde the Logarithme of any absolute number, tangent or sine, as if it were by the Table of Logarithms.

Secondly, By these two lines of numbers and foot-measure may be resolved all questions whatsoever, that common Arithmetick can resolve. And more ; for hereby may be resolved all questions of Interest, Purchases, Annuities, &c.

Thirdly, By these three lines of numbers, sines, and tangents is resolved the whole doctrine of Triangles, and whatsoever may be performed by them, either in Measuring, Dialling, Geography, Geometry, Arithmetick, Navigation, Cosmography, Astronomy, &c.

But, because (gentle Reader) I would have thee learn how to go alone ; I will commit these to thine own consideration, knowing that that chicken that will peck up never a corn, but what the hen puts in the mouth, will never be a fat chicken.

Now if the Rule of three is accounted of all men worthy for its excellency of the name of the *Golden-Rule* (which is but the least part of the use of one of the lines of this Ruler) then justly may this Ruler be called the *Golden-Ruler*.

F I N I S.

